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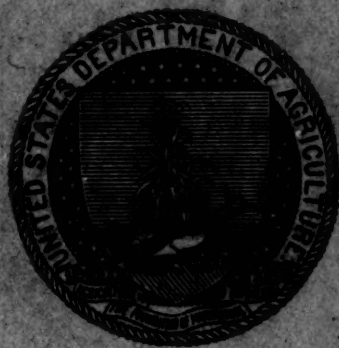
U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 46, No. 6

JUNE, 1918



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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

HERBERT H. KIMBALL, Acting Editor.

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W. B. No. 653.

JUNE, 1918.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW are published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Since August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere*.

SECTION 4.—*Rivers and floods*.

SECTION 5.—*Seismology*.—Results of observations by Weather Bureau observers and others as reported to the Washington office.

SECTION 6.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian

Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1917. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but *all students of atmospheric* are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but are collected and published by States at selected section centers. (See cover, p. 3.)

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.

The Meteorological Service of Cuba.

The Meteorological Observatory of Belen College, Habana.

The Government Meteorological Office of Jamaica.

The Meteorological Service of the Azores.

The Meteorological Office, London.

The Danish Meteorological Institute.

The Physical Central Observatory, Petrograd.

The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JUNE, 1918.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., July 29, 1918.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1918, 46:2.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged very close to its normal intensity at Santa Fe, N. Mex., above normal at Madison, Wis., and below normal at Washington, D. C., and Lincoln, Nebr. A noon intensity of 1.44 calories measured at Madison at noon of June 22 is the highest intensity ever measured at that station in June.

Table 3 shows an excess of radiation at Washington and Lincoln, and only a unimportant departure from the normal amount at Madison.

Skylight polarization measurements obtained on three days at Washington give a mean of 46 per cent with a maximum of 47 per cent. The latter is considerably below the average June maximum. Measurements on six days at Madison, Wis., give a mean of 63 per cent, with a maximum of 69 per cent on the 12th.

No solar radiation measurements were obtained during the solar eclipse of June 8 at any of the above stations, on account of poor sky conditions, except a series at Lincoln, Nebr., extending from 4:53 p. m. to 5:27 p. m., apparent solar time. These give a minimum of 0.088 calories at 5:03 p. m., at which time the sun's true altitude was 25.2°, and the air mass 2.34. The sun's disk was then about 0.9 eclipsed. At this time the Callendar recorder at the same station gave a vertical intensity for the total radiation from sun and sky of 0.075. Since the vertical component of the direct solar radiation measured at this time is only 0.037 calories, the diffuse sky radiation and the direct solar radiation received on a horizontal surface must have been about equal in amount.

A few cirrus and cumulus clouds were present, principally near the western horizon.

TABLE 1.—Solar radiation intensities during June, 1918.

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.										
Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
1918										
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
June 1.....	1.12	1.04	0.95	0.83	0.74	0.66	0.59	0.55		
4.....	1.45	0.76	0.68	0.81	0.72					
5.....		0.76	0.68	0.81	0.72					
10.....		1.42	1.13	1.01	0.81	0.72				
15.....		1.37	1.27	1.16	0.89					
24.....		1.37	1.27	1.16	0.89					
27.....		1.11	1.01	0.91	0.83					
Monthly means.....	1.23	1.04	0.93	0.82	(0.73)	(0.66)	(0.59)	(0.55)		
Departure from 10-year normal.....	-0.05	-0.05	±0.00	-0.01	-0.08	-0.10	-0.08	-0.05		
P. M.										
June 1.....		0.89	0.70		0.50					
4.....		0.73	0.68							
12.....			0.91	0.80						
15.....		1.25	1.15	1.06	0.94	0.82	0.72			
19.....		1.17	1.03	0.89						
Monthly means.....		1.01	0.89	0.92	(0.72)	(0.82)	(0.72)			
Departure from 10-year normal.....		-0.07	-0.10	+0.01	-0.10	+0.08	+0.02			

TABLE 1.—Solar radiation intensities during June, 1918—Continued.

Madison, Wis.										
Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
1918										
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
June 4.....		1.04								
7.....	1.46	1.35	1.26	1.17						
11.....	1.20	1.13								
12.....	1.41	1.33	1.22	1.16	1.11	1.06	1.00	0.95		
14.....	1.32	1.17								
15.....	1.35	1.28	1.20							
17.....	1.32									
21.....	1.37	1.22	1.08	0.96	0.84					
22.....	1.45	1.36	1.25	1.14	1.07	0.99	0.91			
Monthly means.....	1.36	1.24	1.20	1.11	1.01	(1.02)	(0.96)	(0.95)		
Departure from 8-year normal.....	+0.04	+0.03	+0.07	+0.05	+0.04	+0.09	+0.07	+0.13		
P. M.										
June 7.....		1.33								
12.....		1.28	1.18	1.10						
14.....		1.17								
17.....		1.18								
Monthly means.....		1.24	(1.18)	(1.10)						
Departure from 8-year normal.....		+0.08	+0.08	+0.09						

Lincoln, Nebr.										
Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
1918										
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
June 1.....	1.28	1.20	1.12	0.99	0.90	0.83				
2.....	1.22	1.19	1.04		0.94	0.90				
3.....					0.80	0.71	0.62			
11.....	1.38	1.16	1.03	0.94	0.87	0.82				
12.....	1.34	1.23	1.08	1.02	0.95	0.85	0.78			
14.....	1.28									
15.....	1.30									
16.....	1.35	1.22	1.09	0.98						
17.....	1.35				0.82	0.68	0.62			
25.....		1.24		0.99	0.90					
26.....	1.36									
27.....	1.34									
Monthly means.....	1.32	1.21	1.07	0.98	0.88	0.80	0.67			
Departure from 3-year normal.....	-0.03	-0.06	-0.06	-0.06	-0.06	-0.06	-0.09			
P. M.										
June 3.....		1.15								
15.....		1.10	0.97	0.86	0.77	0.68	0.61			
16.....		1.23	1.10	0.99	0.91	0.83	0.76			
17.....		1.24	1.14	1.04	0.95	0.86				
25.....		1.36	1.12	0.99	0.93	0.86				
26.....		1.23	1.10	0.99	0.92	0.86	0.80			
27.....		1.22	1.11	1.03	0.97	0.91	0.84			
Monthly means.....		1.23	1.10	0.98	0.91	0.83	0.75			
Departure from 3-year normal.....		±0.00	-0.01	-0.02	-0.01	-0.03	-0.02			

Santa Fe, N. Mex.										
Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
1918										
A. M.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
June 1.....		1.35	1.23				1.06	1.01		
5.....	1.38					0.96	1.00	0.91	0.87	0.78
7.....		1.21	1.14	1.06	1.00	0.91	0.87	0.78	0.78	0.83
10.....		1.35	1.25	1.18	1.12	1.04	0.96	0.86	0.86	0.83
11.....	1.45	1.36	1.27	1.20	1.12	1.07	1.01	0.97	0.92	
12.....		1.26	1.18	1.10						
13.....					0.99	0.93	0.88			
14.....		1.32	1.21	1.14						
15.....			1.19	1.08	0.99					
24.....		1.31	1.22	1.14	1.09	1.01	0.92			
26.....	1.45	1.35	1.25							
27.....	1.47	1.39	1.31	1.24	1.15	1.07	1.00			
28.....	1.47	1.43	1.36	1.28	1.20	1.16				
29.....				1.07	1.05		0.95			
Monthly means.....	1.44	1.33	1.24	1.15	1.07	1.03	0.95	0.87	(0.88)	
Departure from 6-year normal.....	-0.02	+0.02	+0.01	±0.00	+0.01	±0.00	+0.01	-0.06		
P. M.										
June 26.....		1.36	1.22							
27.....		1.38		1.24	1.20					
28.....		1.39	1.30	1.23	1.19					
Monthly means.....		1.38	(1.26)	(1.24)	(1.20)					
Departure from 2-year normal.....		-0.01	-0.06	+0.01	+0.04					

TABLE 2.—Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1918.	mm.	mm.	1918.	mm.	mm.	1918.	mm.	mm.	1918.	mm.	mm.
June 1	20.57	22.00	June 4	10.97	12.68	June 1	10.21	12.68	June 1	3.81	5.30
4	10.59	11.38	7	6.02	6.50	2	10.59	15.11	5	5.79	5.56
5	14.10	14.60	11	13.13	9.47	3	15.65	14.10	7	5.79	8.48
10	11.38	13.61	12	8.81	9.14	11	12.68	7.29	10	8.18	9.14
12	16.20	10.21	14	11.81	9.83	12	10.97	8.48	11	7.04	4.95
15	9.83	9.14	15	7.57	12.68	14	12.68	17.96	12	5.56	7.04
19	9.14	7.04	17	10.21	7.04	15	17.37	15.11	13	7.29	6.76
24	6.27	8.81	21	7.29	9.47	16	13.13	11.81	14	7.29	5.79
27	10.59	12.24	22	4.75	7.57	17	20.57	11.38	15	6.27	4.95
						25	14.10	9.83	24	9.14	7.29
						26	15.65	9.14	26	7.87	4.95
						27	11.81	10.21	27	5.79	4.95
									28	4.57	5.56
									29	4.17	7.04

TABLE 3.—Daily totals and departures of solar and sky radiation during June, 1918.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Wash- ing- ton.	Madison.	Lin- coln.	Wash- ing- ton.	Madison.	Lin- coln.	Wash- ing- ton.	Madison.	Lin- coln.
1918.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
June 1	603	649	675	110	171	148	110	171	148
2	548	685	676	56	204	144	166	375	292
3	469	254	693	-23	-230	157	143	145	449
4	660	514	497	169	27	-45	312	172	404
5	611	236	550	120	-255	3	432	-83	407
6	400	384	447	-92	-110	-104	340	-193	303
7	302	752	642	-191	255	87	149	62	390
8	696	573	669	202	72	110	351	134	500
9	724	538	606	229	34	43	580	168	543
10	629	410	669	133	-97	102	713	71	645
11	567	671	666	9	160	95	722	231	740
12	551	753	719	52	239	144	774	470	884
13	615	543	662	115	26	83	889	496	967
14	325	707	652	-176	187	69	713	683	1,036
15	723	633	686	221	110	100	934	793	1,136
16	616	544	712	113	18	124	1,047	811	1,260
17	582	674	685	77	145	96	1,124	956	1,356
18	298	355	663	-208	-177	73	916	779	1,429
19	658	469	538	151	-66	-52	1,067	713	1,377
20	606	455	411	98	-83	-180	1,165	630	1,197
Decade departure							452	559	552
21	134	510	714	-375	-31	123	790	599	1,320
22	462	743	512	-48	200	-79	742	799	1,241
23	416	705	580	-95	160	-11	647	959	1,230
24	616	339	432	104	-208	-158	751	751	1,072
25	114	435	719	-399	-114	129	352	637	1,201
26	(*)	461	693		-88	105		549	1,306
27	(*)	288	697		-260	111		289	1,417
28	(*)	585	488		37	-96		326	1,321
29	(*)	563	78		16	-504		342	817
30	(*)	253	757		-294	177		48	994
31									
Decade departure								-582	-203
Excess or deficiency calories since first of year. (per cent.)							-592	+678	+1,499
							-0.9	+1.0	+2.1

* Register undergoing repairs.

CORRIGENDUM.

May 1918, page 208.

Table 1, Santa Fe, N. Mex., last line, "+0.12" should read "-0.12".

A SOUTH PARHELION OBSERVED MAY 1, 1918, AT FRUITA, COLO.

By J. B. WILLSEA, Cooperative Observer.

[Dated: Fruta, Colo., July 2, 1918.]

On May 1, 1918, a south parhelion was seen at this place from 9:15 to 10:48 a. m. (At 10:51 it had vanished.) When last seen it appeared to be about $3\frac{1}{2}$ degrees from the middle of the ring of the accompanying halo. Its disappearance was gradual and no change in the density or other appearance of the cirrus haze was discernible.

NOTE.—Fruta is on the western slope of the Rocky Mountains at an elevation of nearly 1 mile above sea level. Its latitude and longitude are about $39^{\circ} 10'$ north and $108^{\circ} 45'$ west, respectively. The times given are 90th meridian time or, in other words, they are expressed in what is generally known as "summer time." From these data it has been possible to compute the altitude of the sun at the time of disappearance of the parhelion, and the result gives $50^{\circ} 08'$. This description by Mr. Willsea is, therefore, of considerable interest and importance, confirming as it does other observations of the altitude at which parhelia disappear. (See "The Different Forms of Halos and their Observation" by Besson.)¹ In this case the parhelion gradually diminished in brilliancy and had entirely disappeared when the Sun had reached an altitude between 50 and 51 degrees, although no change in the density of the cirrus clouds was apparent.—W. R. Gregg.

LUNAR RAINBOW OF JUNE 24, 1918, AT SALINA, KANS.

By WALTER A. JONES, Cooperative Observer.

I first noticed this phenomenon about 10:15 p. m. and it lasted until 10:40 p. m. (local summer time). The moon was shining brightly in the southeast as a rain cloud approached from the northwest. This cloud was thick and black, with the rain falling gently, and made an ideal setting for the rainbow. The four colors, red, orange, yellow, and green, were easily discernible, and I thought I could distinguish the blue, but it blended with the color of the cloud so closely I could not be certain. Only about three-fourths of the arc was complete on account of the cloud not being high enough. The highest part of the rainbow was about 40° above the horizon.

SOLAR HALO PHENOMENA OBSERVED AT SANTA FE, N. MEX., JUNE 25, 1918.

By CHARLES E. LINNEY, Meteorologist.

[Dated: Weather Bureau Office, Santa Fe, N. Mex., June 25, 1918.]

A rather unusual and beautiful display of halo occurred at this station at 10:25 a. m., 105th meridian time, June 25, 1918. Fine cirrus clouds were passing eastward in rather close formation near the sun, but widely separated farther eastward. At a distance of 22 to 25

¹ MONTHLY WEATHER REVIEW, July, 1914, 42: 438.

degrees from the east rim of the sun a halo appeared, showing probably a third of the circle and beautifully colored, while far down toward the eastern horizon in the midst of the separated groups of cirrus clouds a second line, almost flat, appeared even more brilliant than the near circle. This was so nearly flat that it would have taken a circle of probably 120°-radius to have included it as a segment. The colorings ran red, orange, blue, and green from inside outward, while the smaller circle had principally red and blue. The halos were visible for about 15 minutes and then changing clouds caused them to disappear.

Two of our cooperative observers reported similar phenomena. The observer at Bland, Sandoval County, about 35 miles north of west of Santa Fe, states that on the 25th of June he observed "rainbow clouds from 10 to 11 a. m.," and the observer at (near) Moriarity, Torrance County, about 45 miles south, states that "a double

halo was noted on the 25th with colors of the rainbow, from 10 to 11 a. m." (Standard Time).

NOTE.—The elevation of Santa Fe is 7,013 feet above sea level and its latitude and longitude are 35° 41' N. and 105° 57' W., respectively. From these data and the time of observation given by Mr. Linney the altitude of the sun has been computed to be about 65°. No actual measurements were made, but a sketch furnished by Mr. Linney indicates that the arc observed near the eastern horizon was a circumhorizontal arc, sometimes called the lower tangent arc of the halo of 46°. This report is of considerable interest in view of the small number of observations that have been made of this phenomenon. Besson¹ states that it can be formed only for solar altitudes exceeding 58°, and that only 3 or 4 observations of it are known.—*W. R. Gregg.*

¹ MONTHLY WEATHER REVIEW, July, 1914, 42: 440.

SECTION II.—GENERAL METEOROLOGY.

SOLAR DISTURBANCES AND TERRESTRIAL WEATHER.

By ELLSWORTH HUNTINGTON, Research Associate in Geography.

(Dated: Yale University, New Haven, Conn., Mar. 7, 1918.)

(Continued from this REVIEW, April, 1918, p. 177.)

III. FACULÆ AND THE SOLAR CONSTANT COMPARED WITH BAROMETRIC GRADIENTS.

Faculæ and barometric gradients.

As evidences of the sun's activity, faculæ and the solar constant are presumably no less important than sunspots. Therefore before drawing any final conclusions we may well study their terrestrial relationships in the same way that we have studied those of sunspots. Unfortunately faculæ are visible only near the margins of the sun's disk. Hence, although they are measured as carefully as the spots, the data are far less complete. We can, however, apply to them the method of quadrant differences used in the previous chapters of this memoir, since that method deals with the sun's marginal portions. Table 12 and figure 15 illustrate what happens when there is a marked quadrant difference in the faculæ; that is, when the area of the faculæ in the northwest plus the southeast quadrants of the sun greatly exceeds the area in the northeast plus the southwest quadrants. In figure 15 the dotted line at the top shows the average daily change in barometric gradients in the northern section of the North Atlantic Ocean in respect to 34 days in 1907 when the solar faculæ showed maximum quadrant differences. The solid line has been added for comparison. It illustrates the same conditions in respect to 34 days showing maximum quadrant differences in the *umbræ*. The umbral line shows a marked maximum during the time of solar disturbance. The facular line does the same, but to a less degree. In general the facular line seems to be shifted one or two days to the left of the other. It is impossible to tell whether the faculæ really produce a terrestrial effect or whether they appear to do so because

their area varies roughly in harmony with that of the spots.

The remaining lines of figure 15 represent the barometric variability during 1910-1913 in the northern section of the North Atlantic before and after periods of strong quadrant differences in the faculæ, and the average for both sections of the Atlantic for the five years 1907, 1910, 1911, 1912, and 1913. These lines as a whole present little evidence of any solar relationship. In 1910, to be sure, when sunspots were fairly numerous, the line rises to a pronounced maximum at the end of the time when the quadrant differences of the faculæ were high. In this case, however, as in 1907, the effect may be due to the sunspots and not to the faculæ. In 1911-1913 when there were almost no sunspots, the faculæ were also reduced in numbers, but not to so great an extent as the sunspots. Therefore if their quadrant differences have any effect upon terrestrial weather we should expect some sign of it. Nothing of the kind, however, is apparent.

Instead of beginning with the sun, as is done in figure 15, let us begin with the earth. In figure 16, which is based on Table 13A, the dotted lines represent the facular quadrant differences before and after periods when the Atlantic Ocean suffered an especially severe barometric disturbance such that there was a marked flattening of the barometric gradients in the southern part of the North Atlantic almost coincident with a marked increase in the gradients of the northern section. These conditions are the same as those described in relation to figure 8 [p. 140]. The lines for 1907 and 1910 suggest a relationship between faculæ and storms. In these years, however, sunspots were fairly abundant and the apparent relationship of the faculæ may be due simply to their occurrence in conjunction with sunspots. The years 1911 to 1913, when faculæ were relatively more abundant than sunspots, although both were scanty, suggest no relationship of any kind between the sun and the earth. Hence whether we proceed from the earth to the sun or in the reverse direction it appears that so far as quadrant differ-

TABLE 12.—Changes in barometric gradients in percentages of normal in relation to days of largest differences between the areas of the faculæ in NW.+SE. quadrant and NE.+SW. quadrant (see fig. 15).

	Quadrant differences.	Days before.								Disturbance.					Days after.							
		8	7	6	5	4	3	2	1	1	2	3	4	5	1	2	3	4	5	6	7	8
1907.																						
Cases.....	1,160	5	8	11	12	16	16	20	25	34	19	6	1	0	34	31	28	27	14	11	11	7
Average, northern section		15.6	25.5	14.0	16.1	18.8	12.8	15.6	16.7	20.0	23.1	20.3	12.0	0	17.2	19.1	13.8	13.6	19.1	14.7	18.5	12.4
Average, southern section		13.8	13.0	20.5	26.6	19.4	17.7	15.5	17.5	20.2	17.6	22.1	3.0	0	17.2	17.4	19.5	20.3	15.6	12.4	23.8	18.4
1910.																						
Cases.....	660	8	11	12	12	14	19	20	20	30	11	8	3	2	30	27	25	21	13	12	12	9
Average, northern section		17.7	15.6	12.7	13.6	15.8	13.9	13.9	16.3	18.4	13.6	15.2	11.0	19.5	20.8	17.7	17.8	13.8	13.9	11.2	13.0	17.2
Average, southern section		20.5	12.8	10.8	16.4	15.0	18.8	21.2	20.3	17.6	21.0	21.0	7.9	36.0	16.7	18.4	22.0	20.3	18.8	13.3	23.7	20.0
1911.																						
Cases.....	400	9	9	9	11	12	12	14	17	30	11	4	0	0	30	25	21	19	12	10	9	9
Average, northern section		16.2	19.8	12.8	11.4	16.7	16.4	19.4	14.2	14.5	17.7	7.5	0	0	16.0	16.7	15.6	17.5	16.7	16.8	22.1	13.3
Average, southern section		26.4	14.6	21.2	19.2	20.4	15.3	19.1	17.6	16.8	13.8	18.0	0	0	19.1	12.5	21.4	11.1	20.1	17.6	17.2	14.2
1912.																						
Cases.....	310	6	9	13	13	15	16	17	18	30	16	9	3	0	30	27	21	20	13	13	11	7
Average, northern section		17.2	14.2	11.9	16.0	20.0	15.3	19.6	18.5	18.0	8.8	14.3			14.8	19.2	20.4	16.6	15.3	23.9	14.0	14.1
Average, southern section		15.0	21.5	21.4	13.1	17.5	24.9	23.0	13.1	14.9	17.1	17.8			13.4	19.2	21.7	23.4	16.9	13.7	18.4	19.7
1913.																						
Cases.....	190	6	8	9	10	11	12	12	19	30	17	6	2	1	30	24	22	19	10	9	9	7
Average, northern section		22.0	19.9	20.2	14.0	18.4	18.4	18.0	21.6	21.9	20.2	14.7			15.8	16.8	19.3	19.3	16.4	15.4	24.0	13.4
Average, southern section		21.3	13.9	10.0	9.7	20.3	14.9	11.0	19.0	20.1	17.1	20.0			18.0	13.7	12.0	14.1	28.7	23.9	25.0	21.1

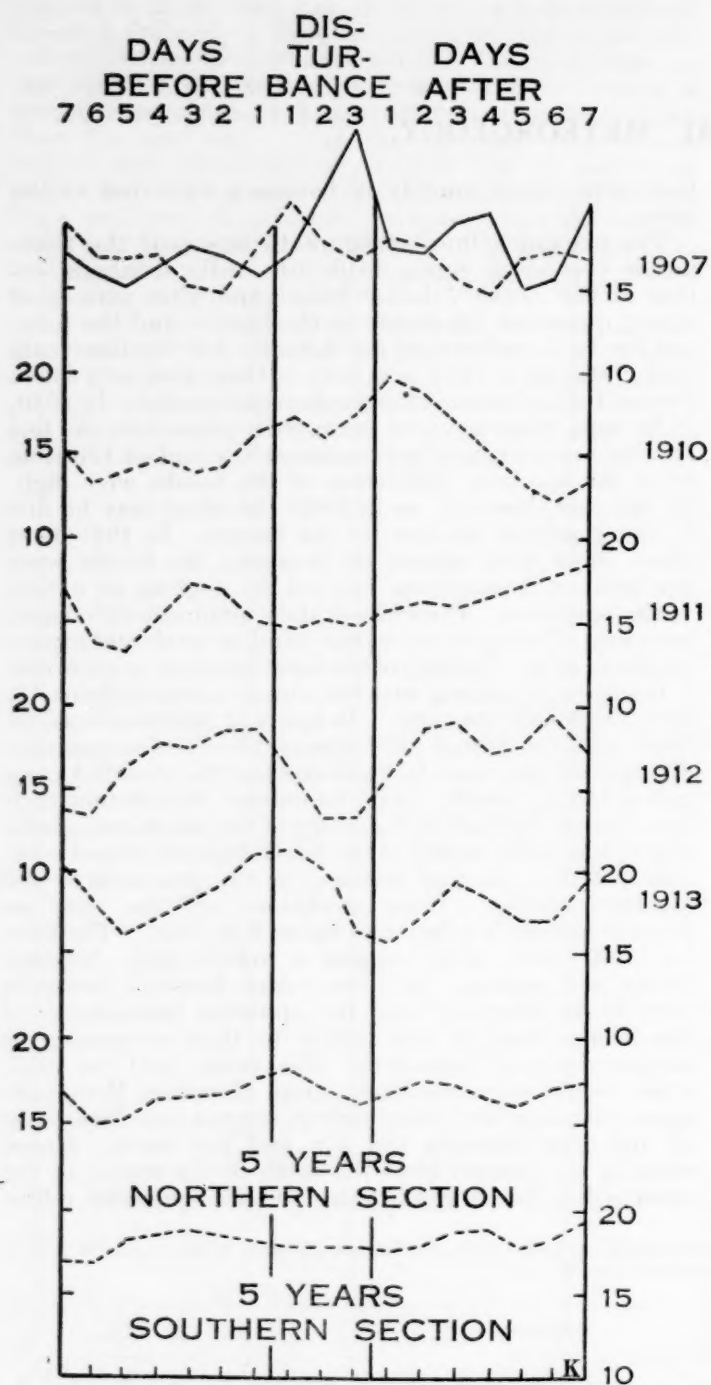


FIG. 15.—Changes of barometric gradients in relation to quadrant differences of faculae. (See Table 12.)

ences are concerned faculae probably are not important. They may have another type of relationship as we shall soon see, but that is a different question.

TABLE 13A.—Quadrant difference of faculae in relation to periods of marked barometric disturbance in Atlantic Ocean involving either low gradient or a sudden decrease of gradients in southern part accompanied or closely followed by a great increase in strength of gradients in northern part (see fig. 16).

Year.	Days preceding barometric disturbance.										0	Days following barometric disturbance.										Number of days.
	10	9	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	10	
1907.....	2,000	1,971	1,768	2,079	1,671	1,717	1,747	1,835	1,867	1,804	1,673	2,329	2,013	1,529	1,214	1,795	1,636	1,665	1,758	1,613	1,931	29
1910.....	877	934	686	850	775	959	1,188	985	1,210	1,145	1,366	998	996	927	1,019	942	819	603	1,025	1,242	1,092	26
1911.....	589	605	647	542	691	524	533	572	564	563	531	466	631	545	411	537	495	592	507	468	543	26
1912.....	380	555	272	323	308	217	154	315	363	269	307	275	403	351	368	381	402	354	418	459	357	21
1913.....	167	220	204	169	201	201	146	205	196	247	221	292	231	240	243	177	197	207	228	211	188	27
Sums.....	4,013	4,285	3,577	3,963	3,646	3,618	3,768	3,912	4,200	4,028	4,098	4,270	4,274	3,592	3,255	3,832	3,549	3,421	3,936	3,993	4,111	129

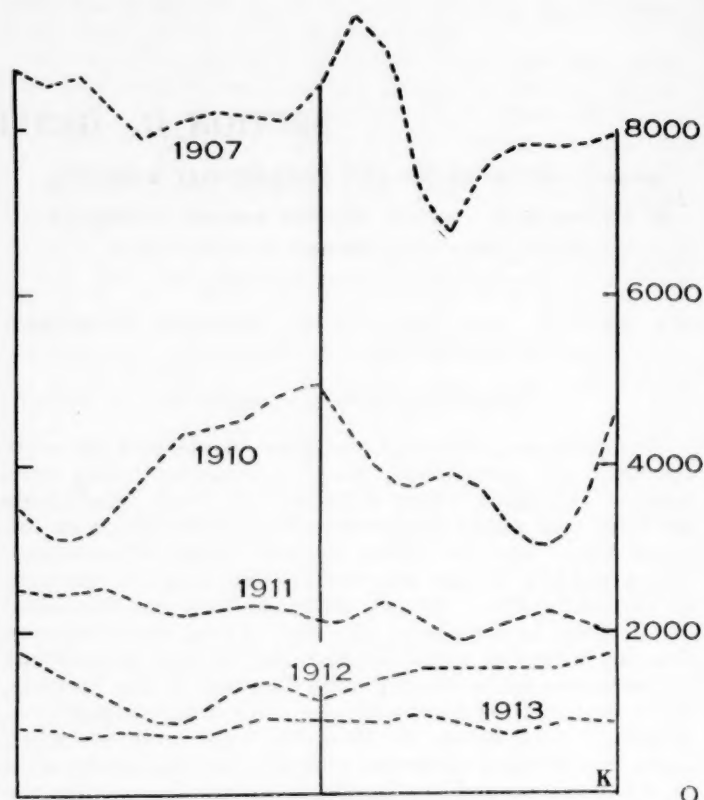


FIG. 16.—Quadrant differences of faculae in relation to periods of special storminess in the Atlantic Ocean. (See Table 13-A.)

Comparisons between solar constants and barometric gradients.

Let us next compare the earth's changes of weather with the solar constant. This is done in Tables 14 and 15, and in figures 17 and 18. The method employed for figure 17 is almost the same as in the previous tables and diagrams, but differs a little because the figures for the solar constant are not available for every day nor for the whole year. For the years 1906, 1908, and 1909 I have selected all the days, 76 in number, having a solar constant of 1.950 or more, according to Abbot. For each of these days the change of gradients in the northern and southern sections of the North Atlantic Ocean has been tabulated and also the change on each of the 8 preceding and the 15 succeeding days. This method puts all the days with high constants into a single group, no matter whether they are the first or later days of a disturbed period. It also causes the gradients of some days to be tabulated twice, since they fall before one disturbance and after another. If the method were applied to line A in figure 10, for instance, it would cause the maximum to occur on the day corresponding to the zero of figure 16. The maximum would not be

TABLE 13B.—Total areas of faculae in relation to periods of marked barometric disturbances in Atlantic Ocean involving either low gradients or a sudden decrease of gradients in southern part accompanied or closely followed by a great increase in strength of gradients in northern part.

NOTE.—This table is not illustrated by a diagram because it adds no new idea. In general it confirms the idea that faculae as well as sunspots—but to a less marked degree—are usually numerous at about the time when barometric disturbances are especially marked.

Year.	Days preceding barometric disturbance.										0	Days following barometric disturbance.										Number of days.
	10	9	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	10	
1907.....	5,479	5,674	5,428	5,640	5,524	5,149	5,610	5,444	5,683	5,586	5,849	5,791	5,525	4,995	5,048	5,610	5,828	5,833	5,424	5,440	5,734	29
1910.....	2,461	2,230	2,256	2,664	2,515	2,433	2,521	2,410	2,704	2,719	2,744	2,649	2,699	2,920	2,781	2,532	2,512	2,364	2,725	2,760	2,590	26
1911.....	966	1,040	1,096	1,146	1,061	1,019	1,031	995	1,117	1,089	1,145	1,076	1,057	1,053	987	1,022	948	1,106	1,095	1,174	1,083	26
1912.....	450	596	450	501	361	280	253	339	450	363	334	371	499	437	511	523	574	559	564	534	584	21
1913.....	206	271	240	212	211	227	167	231	217	247	236	314	230	240	221	242	273	235	276	221	257	27
Sums.....	9,582	9,811	9,470	10,163	9,672	9,108	9,582	9,419	10,171	10,004	10,308	10,201	10,010	9,645	9,548	9,929	10,135	10,097	10,084	10,129	10,248	129

TABLE 14.—Changes in barometric gradients in relation to days having a solar constant of 1.950 or more (see fig. 17).

Year.	Northern section of North Atlantic.																								
	Days before high solar constant.								0	Days after high solar constant.															
	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1906.....	409	433	317	470	267	333	377	389	389	443	456	423	433	426	457	401	421	405	389	461	471	409	382	418	
1908.....	655	674	632	441	594	506	472	500	485	523	602	457	597	448	588	539	585	696	688	544	504	553	566	663	
1909.....	281	231	289	275	305	330	296	318	194	208	234	330	253	193	313	313	334	251	185	251	288	281	311	227	
Total.....	1,345	1,338	1,238	1,186	1,166	1,169	1,145	1,207	1,068	1,174	1,292	1,210	1,283	1,067	1,358	1,253	1,340	1,352	1,262	1,256	1,263	1,243	1,259	1,308	
Mean=Total÷76.....	17.7	17.6	16.3	15.6	15.3	15.4	15.1	15.9	14.1	15.4	17.0	15.9	16.9	14.1	17.9	16.5	17.6	17.8	16.6	16.5	16.6	16.3	16.5	17.2	

Year.	Southern section of North Atlantic.																								
	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1906.....	423	502	426	435	592	583	359	517	475	488	485	664	478	441	513	615	517	525	608	536	301	449	576	461	
1908.....	709	639	665	605	599	590	659	555	573	632	574	556	653	704	509	586	593	621	611	617	715	762	502	634	
1909.....	371	286	263	225	268	383	238	277	332	374	294	301	257	305	328	356	313	311	219	243	353	401	328	338	
Total.....	1,503	1,427	1,354	1,265	1,459	1,556	1,256	1,349	1,380	1,494	1,253	1,521	1,388	1,450	1,350	1,557	1,423	1,457	1,438	1,396	1,369	1,612	1,406	1,433	
Mean=Total÷76.....	19.8	18.8	17.8	16.7	19.2	20.5	16.5	17.7	18.2	19.7	16.5	20.0	18.3	19.1	17.8	20.5	18.7	19.2	18.9	18.4	18.0	21.2	18.5	18.9	

TABLE 15.—Departures of barometric gradients from normal in the North Atlantic Ocean in relation to days with high and low solar constants in the years 1906, 1908, and 1909 (see fig. 18).

SOUTHERN SECTION.																									
Day.....	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
High constants.....	.....	-0.7	-0.4	-0.6	-1.7	-2.2	-1.5	-0.2	0.0	+0.2	+0.7	+0.7	+0.5	+0.7	0.0	-0.9	-1.0	-1.4	-1.7	-0.7	+0.6	+1.0	+0.3	-0.8	-1.0
Low constants.....	.....	+0.3	+0.3	-0.2	-0.1	+0.6	+0.7	+0.1	-0.8	-1.0	-0.7	-0.4	-0.1	+0.2	-0.1	-0.1	+0.2	+0.5	0.0	-0.4	-0.5	+0.1	+0.5	+1.0	+1.0
Day.....	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
High constants.....	-0.5	+0.1	+0.4	+0.4	-0.3	-0.9	+0.4	0.0	+0.1	+0.5	+1.1	+1.1	+1.0	+1.3	+1.2	+0.4	+0.3	+0.5	+0.4	+0.8	+1.6	+1.9	+1.6	+1.6	+1.5
Low constants.....	+1.0	+0.6	-0.3	-0.6	-0.5	+0.4	+1.6	+2.0	+1.3	+1.1	+1.1	+0.9	+1.1	+1.2	+1.2	+1.6	+1.6	+1.0	+0.7	+0.8	+0.9	+0.6	-0.1	-0.3	-0.6

NORTHERN SECTION.																									
Day.....	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
High constants.....	.....	-2.6	-2.3	-1.7	-0.1	+0.7	+0.6	+1.4	+2.1	+1.7	+0.7	-0.6	-0.8	+0.4	+0.4	+0.2	-0.1	-0.1	+0.5	-0.3	-2.0	-2.2	-2.1	-1.4	-0.6
Low constants.....	.....	+2.5	+1.8	+1.3	+0.3	+0.5	+0.6	-0.3	-1.2	-2.1	-2.6	-1.5	-0.7	-0.9	-0.6	+0.3	+0.8	+0.2	+0.9	+0.4	+0.3	-0.7	-1.5	-1.1	+0.3
Day.....	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
High constants.....	-0.7	-1.0	-0.6	-0.7	-0.7	-0.4	-0.3	-0.1	+0.7	+1.0	+0.4	+0.3	+0.8	+0.8	+0.2	+0.3	+1.8	+2.9	+2.0	+0.6	+1.2	+2.3	+2.2	+1.6	+1.1
Low constants.....	+1.2	0.0	-1.4	-1.1	+0.3	+1.2	+0.5	-1.2	-1.3	-0.7	-1.2	-1.6	-0.2	+1.3	+1.4	+0.8	+0.5	+0.6	+0.8	+1.2	+1.0	+0.4	+0.1	0.0	-0.3

so high as now and the decline on either side would be more gentle. Nevertheless, the evidence of relationship between the sun and the earth would be as unmistakable as now and there would appear to be an immediate terrestrial response to solar changes.

According to the method here used a good many days of high constants are tabulated among the days preceding and following high constants. They tend to minimize whatever relationship may exist, but do not wholly obscure it. All the days of reference are characterized by high constants, whereas among the other days a

smaller number is thus characterized as the interval before or after the day of reference increases.

In figure 17 the solar constant as thus tabulated seems to show a possible relation to terrestrial weather. The relation is, however, quite different from that of sunspots.

Provided they are smoothed, the lines for both the northern section of the North Atlantic, A, and the southern section, B, are at a minimum either on the day of the highest solar constant or the day before. From that time onward they rise irregularly for 8 or 9 days. Line C, showing the average for both sections of the North Atlantic, begins to

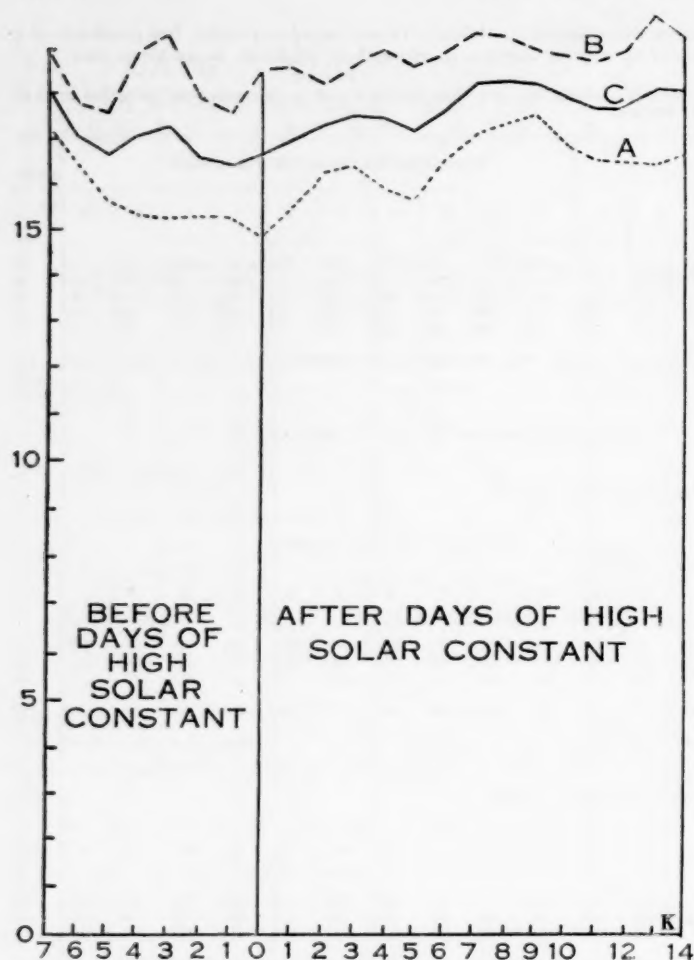


FIG. 17.—Changes in barometric gradients in the North Atlantic in relation to 76 days with solar constants of 1.950 or more, in 1906, 1908, and 1909. (See Table 14.) B, Southern section; C, both sections; A, Northern section.

rise on the day when the solar constant becomes high. If it were possible to obtain more complete figures of the solar constant, the line would doubtless smooth itself out. Just where the line would reach a maximum is not evident, perhaps on the 8th day after the high constant, but possibly not till later. However this may be, the general conclusion is clear. High solar constants during the years in question were followed by a slow but steady increase in the strength of the barometric gradients. The effect is apparently the same as that of an increase in the number of sunspots except that it acts more slowly. We may perhaps compare the temperature effect to the slow gentle rise of the tide, while the sunspot effect is like the shorter and more violent waves raised by the wind.

The relation of the solar constant to barometric gradients is illustrated in a slightly different way in Table 15 and figure 18. In preparing these the days for which solar constant observations are available in 1906, 1908, and 1909 were divided into three approximately equal groups for each year on the basis of the solar constant. The groups with the highest and lowest constants, respectively, were used as the basis for tabulating the departures of the barometric gradients from the normal in both sections of the North Atlantic for a period of 50 days after the days of high or low constants. The smoothed results appear in the upper four lines of figure 18. In the lower part of the figure the two sections have been combined. The lines for high and low constants are

here referred to different zeroes in order that they may stand out clearly. In general both sections show the same features, but these are much stronger in the north than in the south. From the lower solid line, E, it is clear that after days of high constants there is a steady increase in the variability of the weather in the North Atlantic. This culminates in 8 or 9 days, after which there is a slow decline. Low constants, F, on the contrary, are followed by a decrease in the variability of the weather. This culminates in 9 or 10 days.

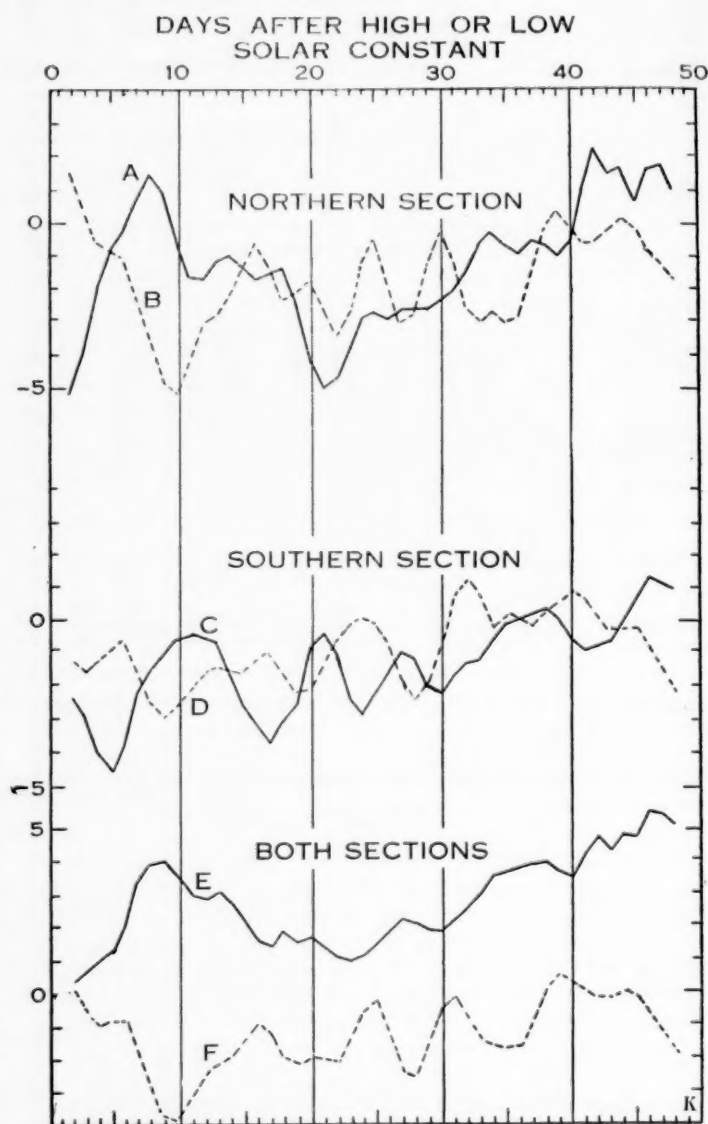


FIG. 18.—Departures of barometric gradients from normal in the Atlantic Ocean after days of high solar constants and low solar constants, 1906, 1908, 1909. low solar constants. — high solar constants. (See Table 15.)

Both curves in the lower part of figure 18, but especially the one for high constants, show an upward tendency in their right-hand portions. Much if not all of this is due to the fact that this particular diagram represents an early stage in the present investigation. It is based on the actual indices for barometric gradients as obtained by counting intersections of isobars with the degree net. The numbers thus obtained were not reduced to percentages of the normal. From midsummer onward, which happens to be the period when most of the solar constant observations are made, the gradients increase in steepness. Therefore during a period of 50 days the amount of change

from day to day is bound to increase because of the increasing severity of the season. Hence for our present purpose the general rise of the lines in figure 18 has no significance. The sudden initial rise of the solid lines and fall of the dotted ones, however, are highly important. They indicate an important relationship between the sun's thermal radiation and terrestrial atmospheric disturbances.

Relation of faculæ to the solar constant.

Let us now turn back to the faculae once more. They are generally agreed to be hotter than the sun's general surface. Hence, they would be expected to produce an effect similar to that of the solar constant. When they first appear on the sun's margin, however, their effect would be slight, just as the effect of the rising sun is slight. If the faculae retain their heat sufficiently long, as they probably do, they would send the maximum supply of heat to the earth 6 or 7 days after their first appearance; that is, when they are near the sun's center. Thus at that time they would cause a high solar constant. We have seen that high gradients occur about 9 days after high constants. Therefore 9 days after abundant faculae reach the central meridian and about 16 days after they are visible on the sun's eastern margin we should look for high gradients. Table 16 and figure 19 show that this is almost what occurs. The table and diagram are based on the year 1907, which had abundant sunspots, and 1910-1913, which had few. The method of tabulation is like that already described; that is, after each period of abundant faculae only those days are included which occur before another period of abundant faculae arrives to confuse matters. Unfortunately the number of periods for which the full quota of days is available is small, as appears in

the table. For the entire North Atlantic, as appears in figure 19, the gradients reach a slight maximum 5 days after the faculae have become abundant on the eastern edge; that is, when they are close to the central meridian.

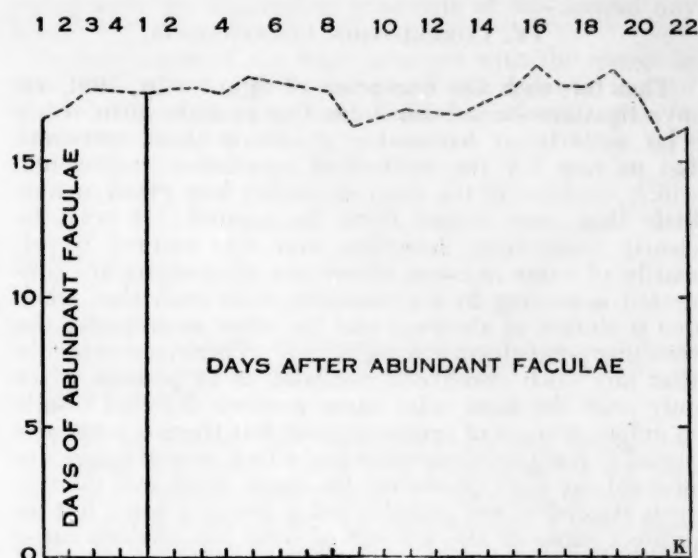


FIG. 19.—Changes in barometric gradients in northern section of the North Atlantic, in relation to faculae on the sun's eastern margin. (See Table 16.)

A stronger but relatively slight maximum appears on the sixteenth and nineteenth days. This is quite closely in accord with what would be expected theoretically. Since it is preceded by a minimum on the ninth day, however, its importance is probably not great. So far as any conclusion is possible, we may say that the faculae tend to show a delayed and inconclusive relationship to terrestrial

TABLE 16.—Changes in barometric gradients in relation to days when the total area of faculae on the sun's eastern margin amounts to 150 or more (see fig. 19).

	Days of abundant faeculae.				Days after abundant faeculae.																							
	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1907.																												
Number of cases.....	37	14	6	3	36	29	23	22	19	17	16	13	12	11	11	10	9	7	7	5	5	4	3	3				
Average change in north- ern section.....	17.2	21.0	13.0	34.3	18.7	20.8	12.6	23.5	15.1	14.3	17.0	20.2	15.8	14.6	18.4	15.4	16.8	18.0	9.7	33.2	14.8	13.0	10.3	4.3				
Average change in south- ern section.....	16.4	14.0	22.0	20.3	18.5	21.5	22.0	17.0	18.3	13.9	24.1	22.4	11.5	10.0	15.4	16.4	20.9	19.7	26.6	25.4	30.2	24.3	21.0	8.0				
1910.																												
Number of cases.....	29	8	5	3	29	24	20	18	15	14	13	13	13	12	12	12	10	8	8	7	7	6	6	6	5	5	5	3
Average change in north- ern section.....	18.7	9.0	23.2	32.3	14.5	21.1	13.1	18.1	13.5	16.6	14.4	17.5	15.9	14.0	17.7	16.3	16.1	10.5	16.0	13.0	19.2	11.2	20.0	10.0	18.6	14.0	11.4	17.3
Average change in south- ern section.....	16.7	30.1	17.2	24.0	18.7	22.4	23.0	16.9	16.2	23.2	16.6	23.8	16.4	20.0	18.3	16.0	14.6	11.2	11.5	19.0	11.3	26.6	23.2	31.0	16.4	18.0	20.6	12.3
1911.																												
Number of cases.....	27	11	8	8	27	24	21	16	15	15	14	14	13	11	11	10	10	9	9	7	6	5	5	4				
Average change in north- ern section.....	19.4	10.2	19.1	19.1	15.8	18.1	16.1	17.4	18.2	11.8	18.9	13.3	27.4	20.8	18.5	17.6	15.3	22.4	28.6	20.4	19.3	19.8	33.2	15.0				
Average change in south- ern section.....	11.7	24.9	13.4	12.6	13.1	11.3	12.8	16.6	18.9	14.7	14.8	16.0	12.5	17.6	17.4	12.2	11.2	15.6	17.4	23.6	12.0	16.0	18.4	13.8				
1912.																												
Number of cases.....	27	13	7	6	27	24	23	23	23	21	19	18	18	16	13	12	9	9	8	6	6	6	6	6	6	5	5	4
Average change in north- ern section.....	18.6	10.2	14.3	19.8	17.2	17.0	17.1	13.6	16.7	22.8	11.7	15.3	15.2	18.7	25.2	13.2	19.2	16.4	13.6	18.2	20.7	17.7	13.8	15.3	18.5	11.0	13.0	17.8
Average change in south- ern section.....	16.9	11.5	21.5	13.5	15.5	21.7	21.1	23.4	20.8	17.3	18.7	19.9	22.6	12.9	18.2	16.6	22.8	19.9	16.9	13.7	7.8	23.8	20.1	21.6	9.0	23.0	13.6	20.8
1913.																												
Number of cases.....	28	10	4	5	28	24	21	21	19	18	18	17	16	14	13	12	8	7	7	6	6	6	2	2	2	2	2	2
Average change in north- ern section.....	21.3	15.0	24.3	20.6	16.5	15.6	17.3	14.8	19.1	19.8	20.1	17.1	13.9	14.5	18.3	18.6	18.4	6.9	15.6	17.7	18.8	18.0	16.5	46.5	25.5	17.0	32.5	39.0
Average change in south- ern section.....	22.9	16.5	22.3	22.6	18.3	14.7	16.9	17.8	26.4	23.2	17.3	19.2	12.1	12.4	12.4	14.8	9.0	19.3	21.0	15.5	18.8	7.2	3.5	16.0	6.0	19.0	15.0	31.0

weather. This is probably thermal, and may be connected with the solar constant. It appears to be of a different type from the relationship which seems to connect sunspots and the weather.

IV. CORRELATION COEFFICIENTS.

Thus far, with the exception of figure 9 [p. 169], our investigations have been limited to periods when either solar activity or barometric gradients show extremes. Let us now try the method of correlation coefficients, which employs all the days no matter how much or how little they may depart from the normal. It must be clearly understood, however, that this method is primarily of value in cases where two phenomena are connected according to a systematic ratio such that when one is plotted as abscissas and the other as ordinates the resulting points form a straight line. There is no evidence that any such conditions confront us at present. Not only does the same solar cause produce *different* results in different types of pressure areas, but there is a *variable period of delay* between cause and effect, *several causes* are probably at work producing the same effect, and *the sunspots themselves are probably not a primary cause* but an indirect cause or else a result of some less obvious cause which also produces barometric disturbances. In fact, so many are the complicating factors that it will be highly significant if the use of correlation coefficients leads to any systematic confirmation of our conclusions, no matter how small.

Nevertheless, the method of correlation coefficients is so exact that it will be worth while to use it. First, however, the reader should recall the reasons why only the smallest coefficients can be expected even if solar variations are closely connected with barometric disturbances. Some of these reasons have already been stated in connection with a discussion of the conditions which prevent the earth's barometric variability from falling to a low ebb even when quadrant differences apparently cease to occur in the sun. The matter is so important, however, that it will pay to think of it once more.

In the first place, the method of correlation coefficients does not distinguish between the cyclonic and anticyclonic conditions which succeed one another at frequent intervals, even in regions of prevailing low pressure such as the northern section of the North Atlantic Ocean. The present investigation, like those of Hildebrandsson and others, seems to show that cyclonic and anticyclonic areas have an inverse relation to the sun. Hence when correlation coefficients are computed, the two types of barometric conditions tend to neutralize one another. Thus any coefficients which we may find represent only the amount by which one type of pressure prevails over the other.

In the second place, even at its point of origin, each new barometric disturbance is superposed upon the more or less vigorous remnants of previous disturbances. Some of these disturbances may have been associated with solar conditions which prevailed one or two weeks before. Moreover, a given disturbance can rarely be measured at its inception. According to the method employed in this paper, it may be measured only on its day of origin and may then disappear beyond the eastern side of the map, or it may be measured on its day of origin and for two to eight days afterwards as it crosses the map, or it may not be measured till several days after its origin, when at last it enters the area of the map. Any attempt to obviate this difficulty by selecting only the

disturbances arising immediately from solar activity would involve the element of human judgment to such a degree that the results would be worthless. As the matter now stands, the element of human judgment in this particular phase of the problem is eliminated, although at the cost of greatly reducing the real coefficients.

A third reason why the method of correlation coefficients can not be expected to give striking results is the fact that barometric disturbances are due to many causes. Some of these are terrestrial. They include volcanic eruptions, forest fires, the heat sent out by great cities, periods of cloudiness, heavy rain, coatings of snow, and other meteorological accidents. Far more important than this is the great basic fact of meteorology, namely the variation in the amount of heat received on a given portion of the earth's surface because of changes in the sun's altitude both from hour to hour and from season to season. By reducing our barometric data to percentages of the daily normals we have largely eliminated the effect of the seasons, and have thus taken out the major correlation coefficient between the earth and the sun. It has been impossible, however, to eliminate the effect either of daily changes in the sun's altitude or of meteorological accidents or of minor occurrences like volcanoes. These all unite to conceal whatever correlation may actually exist between daily barometric gradients and daily solar disturbances.

Finally, the correlation between the atmosphere and the sun is reduced by solar conditions perhaps as much as by terrestrial. In the first place, we have no assurance that any one particular type of solar measurement gives a true measure of the energy available for the production of barometric disturbances. We have already seen that sunspots, the solar constant, and faculae all seem to show some relationship to such disturbances. The relation of sunspots to terrestrial pressure seems to be immediate, whereas high solar constants are followed by high barometric gradients only after an interval of 8 or 10 days. Faculae, on the other hand, seem to show both an immediate and a delayed relationship, but in a weakened indefinite form. Whatever may be the explanation of this apparently twofold relationship, it must blur the correlation coefficients. Moreover, the solar energy, no matter what its nature, must be transformed into kinetic energy before it can manifest itself in barometric pressure. In other words, heat or some other type of energy must be transformed into the kind of energy that moves the particles of air. Such a transformation causes delay and is almost inevitably accompanied by the wasting of energy. Hence it must cause still further reduction in the coefficients.

In view of these considerations we should not expect high correlation coefficients between solar changes and the earth's atmospheric pressure even though the relation is important. For example, with our present imperfect methods it would be a great mistake to expect the coefficients to be anything like so large as those which Clayton¹ has found between terrestrial temperature at inland tropical stations and the solar constant. The temperatures of the earth and the sun are so obviously in direct relation to one another that in this case we should expect a high correlation coefficient. Clayton finds that the average temperature of five-day periods at Pilar, in central Argentina, during the years 1913 and 1914 gives the following positive correlation coefficients when compared with the solar constant for five preceding days.

¹ Effect of short-period variations of solar radiation on the earth's atmosphere, by H. Helm Clayton. Smithsonian Institution, Washington, May, 1917.

TABLE 17.

(After Clayton, op. cit., p. 6.)

Days following solar observations....	0	1	2	3	4	5
(A) Correlation coefficient with maximum temperature.....	+0.41	+0.52	+0.53	+0.48	+0.38	+0.25
(B) Correlation coefficient with mean temperature.....	+0.07	+0.27	+0.35	+0.35	+0.28	+0.14

As the probable error of the maximum in line A is only ± 0.048 , or less than one-eleventh of 0.53, the correlation seems to be so strong as to be beyond question. Clayton has confirmed this result by a similar study of stations in other parts of the world. Hence it seems fairly certain that changes in the sun's thermal radiation are soon followed by corresponding changes in the temperature of the lower layers of the atmosphere. The maximum effect occurs from one to three days after the solar cause.

In the case of so indirect and complicated a relationship as that between atmospheric pressure and solar changes we should expect the coefficients to be much smaller than in the case of temperature. For three tropical stations Clayton found that during 1913 the correlation between the solar constant and the pressure was negative for five days after the days of solar observation, but was too small to be significant, as appears in the first line of Table 18. In the other zones the coeffi-

TABLE 18.

(After Clayton, op. cit. p. 10.)

Days following solar observations....	0	1	2	3	4	5
Correlation coefficient at 3 tropical stations.....	-0.05	-0.03	-0.04	-0.04	-0.01	-0.02
Correlation coefficient at 2 temperate stations.....	+0.09	+0.10	+0.12	+0.13	+0.13	+0.08
Correlation coefficient at 2 arctic stations.....	+0.12	+0.04	± 0.00	-0.03	-0.07	-0.07

cients are a little larger than within the Tropics and arrange themselves in the systematic order shown in the last two lines of Table 18. These coefficients are small, but in view of the complexity of the relationship and the regularity with which they arrange themselves they probably show a real relationship.

When the same method is applied to the correlation between the sun's quadrant differences for 1905 and the barometric gradients of the northern section of the North

Atlantic, according to the formula $r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$, the results are as appear in Table 19.

In this formula r is the ratio, or correlation coefficient; x is the daily departure of the solar quadrant differences from the normal for the year; and y is the daily departure of the barometric gradients from the normal for the day in question, with due allowance for the seasons as explained in the early part of this paper (cf. pp. 125-126).

TABLE 19.

Days before or after solar observation.	Days before.				0	Days after.		
	4	3	2	1		1	2	3
Correlation coefficient.....	-0.075	-0.125	-0.128	-0.105	-0.054	+0.043	+0.092	+0.084

Probable error, ± 0.05 .

The figures in Table 19 are of the same order as those obtained by Clayton for his two stations in the Temperate Zone. They arrange themselves with great regularity. The maximum is found when a given solar condition is compared with the barometric gradients of the second day after.

A comparison of the solar constant with the *change* in gradients from day to day in the North Atlantic instead of with the actual gradients yields the result shown in Table 20.

TABLE 20.

Days before or after solar observation.	Days before.			0	Days after.			
	3	2	1		1	2	3	4
Correlation coefficient.....	-0.029	± 0.000	+0.054	+0.085	+0.125	+0.069	+0.065	+0.026

Probable error, ± 0.05 .

Here, as before, the coefficients arrange themselves with great regularity, rising to a maximum on the first day after the solar observations. This again agrees with our previous conclusions. It suggests that a given solar condition causes a change in the barometric gradients almost at once, so that this appears on the day in question and reaches a maximum on the succeeding day. On the second day after the day of solar observation the gradients are strong or weak in harmony with the preceding solar quadrant differences. Thus the conclusions drawn from correlation coefficients are entirely in accord with those drawn from other lines of evidence.

It might be supposed that a comparison of the barometric conditions with the solar condition during several preceding days would show a stronger relationship than when the comparison is limited to one day. This is not the case, however. When the quadrant differences for successive periods of four days during 1905 are compared with the barometric conditions of the last day in each period the correlation coefficient for the actual gradients is $+0.099$ and for the change of gradients $+0.115$. Here, however, as in the other cases, the correlation coefficients are consistent with our conclusions derived from other methods, which indicates that they are probably of real importance.

Another reason for believing that these correlation coefficients, though small, are of genuine significance is found when they are compared with the coefficients between faculae and barometric gradients. The faculae, like the sunspots, are reckoned in terms of quadrant differences, and the same days are used as in Table 19, above. The result, as shown in Table 21, is quite different.

TABLE 21.

Days before or after facular differences.	Days before.			0	Days after.			
	3	2	1		1	2	3	4
Correlation coefficient.....	-0.024	-0.023	-0.018	+0.006	+0.006	-0.037	-0.0018	+0.002

Probable error, ± 0.05 .

Here the maximum coefficient is only one-fourth as large as in Tables 19 and 20. Moreover, the coefficients are not arranged systematically and are smaller than the probable error. Thus they confirm our previous conclusion that so far as any *immediate* effect upon baro-

metric gradients is concerned the faculae are relatively unimportant and probably owe their apparent effect to their nearness to the sunspots. The fact that in this case the absence of any evidence of a definite relationship is so clear gives reason to believe that the other coefficients obtained both by Clayton and in this paper are of real significance. Small as they are, they are larger than would be expected in view of the many complicating factors discussed on previous pages. Moreover, it must be carefully noted that each of the two sets of eight coefficients given in Tables 19 and 20, as well as each of the other two mentioned in the text, is *systematic*, and also completely in accord with the conclusions derived from other lines of investigation.

SUMMARY.

The net results of the study of solar and terrestrial relationships set forth in this paper and its predecessors may be summed as follows:

(1) Sunspots, faculae, and the solar constant all appear to show a distinct relation to barometric gradients in the North Atlantic Ocean.

(2) The faculae and the solar constant seem to show the same sort of relationships. They act entirely in harmony with the basal assumptions upon which the science of meteorology is founded. Their relation to the weather can be readily explained as the result of the varying amount of heat received upon the earth's surface from the sun. According to Clayton, the maximum heating effect in tropical regions is produced two or three days after the corresponding solar activity. According to the writer's figures the chief effect on barometric gradients in temperate latitudes does not appear until the eighth or ninth day. Thus the time relationships seem reasonable.

(3) The relation between sunspots and barometric gradients is not in harmony with the principles thus far accepted by meteorology. In the first place, although the effect of sunspots is apparently of the same order of magnitude as that of variations in the solar constant, it reaches its maximum with much greater speed. The apparent delay is less than 24 hours. This seems too quick to accord with the ordinary action of heat. In the second place, the effect of sunspots in high-pressure areas is apparently inverse to the effect in low. This seems to be contrary to what occurs when heat is the active agency, for the northern and southern sections of the North Atlantic Ocean appear to respond to the solar constant in nearly the same fashion. A much stronger piece of evidence is the fact that spots on different parts of the sun's surface do not appear to act at all as would be the case as if they emitted heat. The heat of the sun's surface must act most strongly on the earth when the heat radiates from the center of the sun's disk. This appears to be the case with the heat radiated by the faculae. With sunspots the reverse is true. When they are at the sun's center they seem to check the formation of atmospheric disturbances upon the earth. When on the edges, however, where heat would have a minimum effect, they act most vigorously. Moreover, the spots upon the sun's margins do not produce an effect in proportion to their total area, as would be the case if they worked through the emission of heat. On the contrary, a spot on one part of the margin seems to balance a spot on certain other parts. Hence the greatest effects are produced either when what we have called the quadrant differences are at a maximum, or else when the area of the spots on the margin of one quadrant greatly overbalances the area in the other quadrants.

(4) In view of all these facts we seem to be led to the conclusion not only that variations in solar activity are among the prime causes of disturbances in the earth's atmosphere, but that these variations are of two kinds. One kind is clearly thermal. The other kind may be electrical or of some type not yet understood. The discussion of its nature is deferred to another paper.

Meanwhile a word should be added as to the present condition of the great problem of the cause of weather variations. With the appearance of Koppen's final work on sunspots and temperature in 1914 (1) it became almost certain that no further research could alter his original conclusion. That conclusion was that the earth is relatively warm at times when the sun is relatively inactive. This is especially the case in equatorial regions. At about the same time Abbot's measurements of the solar constant (2) made it highly probable that when the sun's surface is active the emission of heat is greater than when the number of sunspots is slight. Thus the meteorological world was face to face with the anomaly of a warm sun and a cool earth. The present author (3) has attempted to explain this by the hypothesis that at times of many sunspots an increase in cyclonic activity, which now seems to be well demonstrated, causes a great amount of warm air to be carried upward. There it dissipates its heat by radiation. This heat is apparently drawn from equatorial regions more than from others. This is partly because convection in the shape of thunderstorms and hurricanes seems to be especially active there during times of many sunspots. Moreover, in the belt of cyclonic storms most of the air that rises in the midst of the more frequent cyclones of periods with many sunspots is drawn from the equatorward side of the storms. Thus at times of many sunspots and a warm sun the earth's surface is most cooled in equatorial regions, less in temperate regions, and possibly not at all in polar regions. When this hypothesis was set forth in 1914 the chief difficulty seemed to be the necessity of postulating some agency other than heat in order to explain the increased cyclonic activity which is supposed to carry away the increased heat received from the sun.

After the present series of papers had been completed in practically the present form, there came to hand the admirable monograph of Helland-Hansen and Nansen. (4) In this they discuss changes in the temperature of the air and of the surface water of the North Atlantic in their relation to ocean currents and winds. With commendable thoroughness they show that, whatever may be the case with variations of long period, the short variations of temperature measured in months do not appear to be due to the movement of ocean currents. On the contrary, the variations occur suddenly over large areas instead of advancing progressively as would be the case if they were carried by the water. In places like Scandinavia it appears, moreover, that changes in barometric pressure and in the temperature of the air over the land slightly precede changes in the temperature of the surface water. This is quite contrary to the usual idea that the temperature of the water determines that of the land. The detailed curves, however, scarcely leave room for doubt. Finally in widely separated parts of the earth, as Arctowski has well shown (5), and as the Scandinavian authors show more fully, the same variations—even in small details—are repeated synchronously. In other equally scattered areas almost exactly the opposite types of variations occur at the same time. Often an area of one kind lies between areas of the other kind. Thus Helland-Hansen and Nansen conclude that the earth's

surface, as Hildebrandsson has already shown (6), is divided into positive and negative centers of action separated by intermediate regions which may be of a transition type, or may be under the sway first of one center and then of another. In these centers, apparently in harmony with solar changes, there occur almost synchronous changes of pressure as well as of temperature. These changes are, apparently, common to all the centers of action, but their character is reversed according as the centers are positive or negative. The changes in pressure appear to precede the changes in temperature. Another noteworthy feature of the centers of action is that one type suffers changes of temperature roughly in harmony with the changes which occur in tropical midcontinental regions and which are apparently due in good part to variations in the radiation of solar heat. The final conclusion of our Norwegian authors is that changes in pressure and winds which are presumably of solar origin, generally precede changes in temperature and are on the whole the more important subject of study.

This conclusion bridges the gap between the present writer's cyclonic hypothesis of variations in temperature and the hypothesis of the present paper as to the effect of nonthermal solar variations. Apparently these solar variations follow a course roughly, but not strictly, parallel with that of changes in the sun's emission of heat. Increased solar heat warms the earth's surface in certain regions, specially within the Tropics or in continental interiors where there are few clouds. This tends to increase the rapidity of both oceanic and atmospheric circulation. At the same time the seemingly nonthermal energy with which we have been mainly dealing in this paper, apparently causes an expansion of areas of high pressure and a consequent weakening of gradients in their centers. This crowds the low-pressure areas and thus in such areas strengthens the gradients. Perhaps, as Veeder has suggested (7), these changes are due to an actual transfer of parts of the upper air toward the centers of high pressure. However this may be, the result seems to be a remarkably quick readjustment of atmospheric pressure. This is apparently followed at once by a strengthening of the winds, and an increase in cyclonic activity. Hence in the high-pressure areas the cold upper air must begin to settle downward, so that the temperature of the earth's surface is lowered. In the low-pressure areas, or at least along their equatorward sides, an unusual amount of warm air must be drawn inward. Thus the temperature rises, and the condition of such places varies inversely to that of the centers of high pressure. Ultimately the warm air is carried upward so that the general temperature of the earth's surface is lowered. This, however, does not happen until certain areas have been warmed by the winds while other areas are being warmed by the sun and still others are being cooled by the descent of air from aloft. One of the next great tasks of meteorologists would seem to be to map the areas of these three types under different conditions of solar activity.

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CORRIGENDA.

PART I.—Page 127, legend for figure 4, the dotted line and the solid line should be interchanged.

Page 129, lower margin of right-hand of figure 5, "increase" should read "decrease."

Page 139, column 2, line 14 from bottom, sentence beginning "Let it" should read "Let us."

II.—Page 170, Table 8, column 1, third line, "1907" should read "1908".

Page 176, second line of note to figure 14, "sun" should read "sun's"; at beginning of fourth line "from" should read "of", and "NS" in same line should read "NE".

LACUSTRAL RECORD OF PAST CLIMATES.

By CHARLES ROLLIN KEYES, Ph. D.

[Dated Des Moines, Iowa, July 14, 1917.]

It is not at all surprising that such apparent climatic anomalies as the occurrence in arid regions of large bodies of inland waters should call forth varied explanations. At first glance interior seas seem to portend former meteorological conditions that were fundamentally different from those now existing. They even suggest that they may be tell-tale clues to epochs when greater humidity prevailed. In this regard the vast extinct lakes of the Great Basin of western North America especially are the theme of warm and prolix discussion on possible climatic changes in late geological times. Whether or not ultimate analysis of recorded observation support the thesis of permanency of climate, rhythmic alternation of climatic change, or variable and irregular succession, it is quite certain that the tendency of opinion toward the middle course thus far finds greatest favor.

When the sumptuous monographs on the vanquished Great Basin lakes were written by King, Whitney, Gilbert, and Russell, such a thing as desert geology was entirely unknown in the United States. Principles of modern physiography were not yet formulated. The tremendous potency of eolic erosion under conditions of aridity was unsuspected. On the other hand, the duality of the Glacial Epoch was just beginning to receive credence, although its real multiplicity and complexity were yet undreamed. Since these new fields of investigation have opened up, old views are capable of something like quantitative measurement, where before much was either pure fancy or unwarranted distortion to fit dimly outlined hypotheses.

Arid regions present as their most characteristic relief expression innumerable shallow depressions. In a tract of close-patterned orogeny as, for example, the Great Basin, these broad depressions are usually coterminous with the intermontane plains. To the explorer fresh from his homeland of humid climate the surface hollows appear as potential lake basins. As a direct consequence of desert erosion they are really not an expression of drainage features at all. That some of them, under such dry-climate conditions, should be actually occupied by broad expanses of water is a wholly unexpected phe-

nomenon; and at first thought the fact appears singularly incongruous.

At the present time the lakes of the notably arid Great Basin possess special interest not only because of their number and the great size of some of them, but on account of the fact that there has been a concerted effort on the part of writers on the region to establish for all of them the same climatic origin. That all of these lakes can not possibly be brought under a single genetic control is only beginning to be realized. That they really have widely different and wholly unrelated origins is amply attested by recent critical observations. That some are composite and others complex is a late conclusion from which there is no escape. Although all the details of the life histories of many of these strange bodies of water are yet to be deciphered, enough is now definitely known to assume that all are capable of satisfactory explanation without recourse to climatic conditions so very different from those now prevailing in the region.

The vastness of expanse of two of the ancient bodies of water in the Great Basin, Lakes Bonneville and Lahontan, is no doubt the chief cause for seeking an adequate explanation by appeal to atmospheric conditions different from those now enjoyed. Instead, however, of a single genetic agency controlling the existence of these two lakes and numerous other smaller bodies of water in the region, recent inquiry indicates rather a multiple origin. In place of an assumed common genesis each lake has to be separately tested concerning its being. Whether classified according to the genesis of lake-basin or according to source of lake waters, there are so many different means of development that any broader controlling agent, as a climatic one, is entirely precluded. Grouped with reference to origin of lake-basin a dozen distinct categories of lakes are found to be represented in the Great Basin. Arranged as to sources of water-supply there are half as many additional categories to be taken into account.

In humid climates the lineaments of lake genesis are masked because of the fact that the barriers are usually overflowing, and it is not always possible clearly to distinguish the underlying factors. In arid lands expansive bodies of water seldom overflow their basins. The specific derivation of each is more or less readily discerned. Even those bodies of water that are close together may have widely different origins. How great then must be the incongruities encountered when such lakes as Bonneville and Lahontan, for instance, are grouped together in the same class, especially when the essential taxonomic factor is made the number of prominent shore-lines corresponding to the number of postulated advances of a continental ice-sheet. The inadequacy of such a climatic test is indicated by the recent recognition of an entirely different number of glacial epochs. Neither of these lakes is to be regarded as arising from imperfect drainage such as ordinarily prevails in pluvial lands. Both are accidental features of the arid country in which they are found.

When the data for the Bonneville and Lahontan monographs¹ were being assembled the novelty of conception of the duality of the Glacial Epoch was noisily occupying the front of the geological stage. The main purpose of these accounts almost seems to have been to establish the truth of the notion. Discovery of two shore terraces more conspicuous than others is cited as indisputable evidence of a twofold Ice Age. Without adducing any

really critical testimony, a marked moderation of the present arid climate is made to account for the lake conditions. Singular as it now seems that recourse should be limited to a single working hypothesis, the fact is easily explained when it is remembered how overpowering in that day was the Glacial argument.

For a long time there has been a general tendency to connect in some way or other the existence of the Great Basin lakes with the presence of glaciers and to associate the desiccation of the former great bodies of water with the waning of the Glacial Epoch. The various views may be all grouped under three heads. Dr. E. M. Endlich was under the impression that the old glaciers of the Rocky Mountains in Colorado were produced by the excessive moisture derived from the broad sheets of water formerly existing to the westward. A second hypothesis, advanced by Prof. J. D. Whitney, regards the Pleistocene lakes as sequels to the glaciers, being produced by their melting. In the "Geological History of Lake Bonneville" Prof. G. K. Gilbert considers that the same changes in climate introduced both the glaciers and the lakes.

The fundamental weakness of both of the last-mentioned hypotheses as general explanations lies in the fact that in the Sierra Nevada, where Whitney mainly worked, the glaciation was sufficiently extensive to be competent to produce the results; while in the Wasatch Mountains, where Gilbert studied, the larger lake was in reach of such petty glaciers that the Whitney explanation could not possibly be sustained.

At the same time that the Great Basin lakes were associated with the regional glaciation there also developed the idea that with the passing of the mountain glaciers the region entered into a stage of general and greatly accelerated desiccation. Whitney, indeed, fancied that all the intermontane plains or basins of Nevada were formerly occupied by beautiful inland seas. But potential lake basins extend far beyond the limits of the Great Basin. They reach southward a distance of 2,000 miles to the Tropics. That these so-called lake basins were really a characteristic surface feature of desert lands generally was not then suspected. Neither was it dreamed that they were not drainage features at all, but owed their origin and prevalence to erosional powers in which running water takes no part. For this reason mainly the real significance of the phenomenon of desert lakes is so often entirely mistaken or largely misinterpreted.

A marked proneness to generalize too widely with regard to these desert lakes, and the attempt to bring all of them under the same genetic head, have done more than anything else to obscure the real issues involved. The forced efforts to consider the ancient bodies of water as glacier-born is only one angle of the problem. Throughout the West the lacustral hypothesis of the origin of geological formations has been so long overworked that it would be no surprise if the reaction that is now setting in against it go much too far. Many of the so-called old lake beds are now known to be fluvial deposits. Still larger numbers are manifestly strictly epirotic in character. Others are partly one and partly the other. Very few are actually lake-laid strata. The widely recognized "Severn Lake" deposits of Nevada are discovered to be marine in origin, at least in large part. In the last-mentioned deposits are fossils as old as the Eocene age, and the strata, infolded as they are in the Sierra Nevada and Sierra Madre, are traceable in a broad belt to the Pacific Ocean. So the published data on the terranal aspects of the ancient desert lakes can

¹ Mon. U. S. Geol. Surv., Vols. I and XI.

not now be viewed with the same equanimity that they were a few years ago. Before confidence is again restored much of the region of the Great Basin has to be critically examined anew.

Without outlining a full genetic scheme of lacustral taxonomy, which arid regions seem to supply the data for in unmasked form, it is important in this connection to note that each body of water requires separate consideration when its genesis is under surveillance. Many desert lakes of consequence are no doubt simply the exposure of the ground-water table to sky, due to local accentuation of the deflative processes. Others, as Lake Bonneville, seem to be due to orographic movements chiefly. Lake Bonneville's history is a long one. It goes back far beyond the inauguration of the Glacial Epoch. To all appearances many traces of its early development are still retained; and they antedate even the coming of the arid climate. Briefly, the course of events seems to be that this vast body of water of which Great Salt Lake is commonly believed to be a last vestige, is not after all an anomaly among desert features, but that it merely represents a special phase of a through-flowing stream that was not quite large enough to master the orogenic barrier which chanced to arise athwart its path. On the other hand, its nearest neighbor and parallel relative, the Green River, reinforced by the Grand and other large eastern tributaries, was sufficiently powerful to hold its own against all vicissitudes and to carve through the rapidly bulging Colorado dome a Titan among chasms. Blocked by such a formidable rampart, the Old Virgen River, as it may be called, spread out far and wide over the adjoining intermontane plains, and rivaled in magnitude the Laurentide Great Lakes, with 20,000 square miles of area and a depth of 1,000 feet. Finally, the principal supplies being diverted, the waters of the great lake were allowed to evaporate until equilibrium was again established between it and its remaining tributaries.¹

That the seemingly vast changes in the water conditions of this desert region were physiographic rather than climatic in their nature finds strong support in the recent results of Prof. W. W. Atwood,² in southwestern Montana. This author shows by quite conclusive evidences that immediately before the inauguration of the Glacial Epoch the basin of the Snake River extended nearly 200 miles farther to the northeastward than it does at the present time, and included an area of nearly 300 miles square that has since been separated from it. This area was mainly that part of the basin of the present Missouri River lying above Great Falls. Passing Idaho Falls and Pocatello, was a combined volume of waters of the present Snake River and the Missouri River at the Great Falls gorge. This noble stream is believed to be the Old Virgen River, the superior companion of the Green River. In the recent migration westward a distance of 150 miles of the Continental Divide in Montana, the Yellowstone River took part of the old Snake or Virgen headwater drainage, the Missouri River the greater portion, Clarke's Fork of the Columbia a part, and the Salmon River of Idaho a part. Deprived of so large a portion of its headwaters, and later blocked by basalt flows at Pocatello, the remnantal pre-Glacial stream turned out over the Idaho lava fields the diminutive Snake River that we find to-day.

In the early considerations of Bonneville Lake the geological age of the attendant deposits was a matter of

extreme uncertainty. Bearing on this point no satisfactory testimony was ever adduced. More recently several distinct but mutually supporting lines of evidence seemed to settle this question. The elevation of the southern mountain barrier of the old valley was manifestly coeval with the formation of the inner gorge of the Grand Canyon of the Colorado River in Arizona—Mid or Late Tertiary in date. At Red Rock Pass, the low-rim point of the basin at the north and an assumed outlet of the lake, the gravels and silts proved to be a direct continuation of the Bozeman beds of southwestern Montana and southern Idaho. In age these were mainly Mid Tertiary. The uplifting of the Beaverhead range athwart the drainage and the capture of the original headwaters of the Snake River by the Missouri River took place in Late Tertiary time. The complete diversion of the Snake River drainage from the Bonneville basin was probably also a Late Tertiary occurrence. Antedating Pleistocene or Glacial times there still remained the Early Quaternary Epoch.

Thus before the Glacial Epoch set in was Lake Bonneville already a mature body of water, it had far passed its widest expansion, and it was really more than two-thirds desiccated. All drainage communication with the Continental Divide about Butte, Mont., being cut off, the lake basin received no augmentation to its waters from the mountain glaciers in this direction. Since the recent careful mapping of the old glaciers of the Wasatch and Uinta mountains the most conspicuous feature brought out concerning them is their utter insignificance. So inconsequential must have been their influence on lake conditions that one can not but wonder why the two phenomena were ever genetically associated. The Glacial Epoch came too late to be witness at the lake's birth. It narrowly escaped not being present at the death.

Whatever may have been the course of events in the history of Lake Bonneville, it is not at all probable that that of the other great body of Great Basin water, Lake Lahontan, had nearly the close parallel which a climatic hypothesis demands. In duration, in expanse, in magnitude of gathering ground the last-mentioned body of water is hardly to be compared in importance with ancient Lake Bonneville. Whether or not Lake Lahontan still retains any vestige of pre-arid drainage lines is hard to say. There are good reasons for believing that it stands in the path of a former through-flowing river that was comparable to the Green or Snake River of to-day. Relatively recent orogenic movements and volcanic disturbances are ample effectually to block the course of any stream that happened to skirt the eastern foot of the Sierra Nevada and to empound its waters. If such a master stream did actually exist in pre-lacustral or pre-arid times, nearly if not all traces have probably long since completely disappeared through the operation of the ordinary desert erosional processes. Yet, in this connection, such features as the thousand-foot-deep canyon at the south end of Death Valley, Cal., now occupied for a number of miles by the little brook called Amargosa River, need careful examination.

The lakes which, in long succession, now lie at the foot of the great orographic block of the Sierra Nevada may be, however, merely the basal reservoirs of the different mountain streams and may have no relations to any former connection with a pre-arid master-stream of the region. In pre-Glacial times these mountain rivers probably were much larger than now, owing to the

¹ Bull. Geol. Soc. America, Vol. XXVIII, p. 351, 1917.

² Economic Geology, Vol. XI, pp. 697-740, 1917.

fact that the position of the Sierra Divide was much farther to the westward than at present. Waning glaciation over this lofty region was certainly competent to appreciably augment the basal lake supplies. It is thus quite possible that Whitney's explanation of melting ice is partly correct.

The disappearance of the great Lake Lahontan, as well as the diminution in size or vanishing of many of the other bodies of water once much larger than now, is readily explained by postulating greatly diminished inflow occasioned not so much by a change from moister climatic conditions as by the rapid eastward migration of the Sierra Nevada watershed and by the capture of its chief catchment basin by the Columbia River. The east base of the great snowy range is 4,000 feet higher than the west foot. Headwater erosion thus goes on so much more speedily on the sunset flank than on the other side that the divide has already nearly reached the eastern margin of the orographic block. Some of these west-flowing streams are now actually crowding down the east slope of the ridge. The headwaters of Feather River in California reach even now quite to the brow of the high escarpment overlooking the Great Basin. Pitt River in the same State has already broken through the range and drains lakes that not so very long ago were strictly Great Basin features. The time can not be long until the canyon of the American River, along the brink of which the Southern Pacific railway runs 3,000 feet above the bottom, shall have been cut back completely through the Sierra, capturing the Truckee River on the eastern side. At a little later date the waters of Humboldt River may be flowing uninterruptedly to the Golden Gate.

Bearing directly on the question of an independent genesis of the two largest lakes of the Great Basin is the attitudes of the minor lakes of the region. Admittedly of a half score distinct origins, these several classes of desert waters retain their characteristics far beyond the confines of the Great Basin. Their congruous relations to normal desert environment continue southward quite to the Tropics; so they are the same in regions far beyond supposed influences of Glacial climate. In climatic discussions of the Great Basin the significance of this fact is little considered. It is one of the strongest arguments against appreciable change in climate since the time when these lakes began to form. The continental glacier front is far too remote to influence the climate of Nevada. All lacustral testimony seems to support conclusively the postulate that during late geologic times the climatic fluctuation in the region has been no more rapid than the larger orographic change. It is doubtful whether during the Glacial Epoch there was any appreciable modification in the climatological features of the arid lands.

CROP CENTERS OF THE UNITED STATES.

By J. WARREN SMITH, Meteorologist.

[Dated: Weather Bureau, Washington, D. C. June 28, 1918.]

Dr. Adolph E. Waller, Associate at the Botanical Laboratory of the Ohio State University, Columbus, Ohio, contributes an article under the above head in the *Journal of the American Society of Agronomy* for February, 1918, vol. 10, pages 49-83, that is of more than

passing interest to students of agricultural meteorology. The author writes from the point of view of the ecologist, and relates farm practice, as shown in the development of commercial field crops, with natural vegetation as influenced by climate and soil.

The article opens with a discussion of the climate of the United States, particularly in the inter-relation of temperature, rainfall, and evaporation, and the effect upon certain marked types of vegetation. Unfortunately, in explaining the influence of high and low pressure areas upon rainfall, the author makes the serious error of saying that "the eastern side of a high and the western side of a low are regions of ascending, converging, cooling air," and is thus "the region of increasing moisture," while "the western side of a high and the eastern side of a low are regions of descending, diverging, warming, drying air." He indicates in the next paragraph that the wind blows away from areas of low pressure, which is contrary to the well-known fact that the wind blows *away* from high and *toward* low pressure areas. While these errors are regrettable, they do not vitiate the general excellence of the paper as a whole.

In his discussion of climatic and edaphic factors, the author states that:

In every stage of their development plants respond to the moisture and temperature changes of the habitat. The nature of the soil has such a far-reaching influence upon plant life that it must be considered second in importance to but one factor, the climate. Those plant-growth factors related to the soil have been named by Schimper (1903) the edaphic factors.

Warming (1909), impressed with the fundamental relation between plant growth and available water supply of the habitat, grouped vegetation into three principal classes, hydrophytes, mesophytes, and xerophytes. The water-content of soils was made the basis of his work, but when he recently reclassified the three types in order to accommodate them more closely to plant distribution, the new system was too involved to receive general recognition from plant geographers. Schimper made practically the same grouping that Warming made of water-content associations. He also pointed out that the terms forest, grassland, and desert are a subconscious classification of the principal climatic formations and are only another way of expressing the water-content of soils.

The effect of the edaphic factors is to modify the climatic influences. The physical and chemical properties of soils tend to diminish or intensify the effect of climatic factors upon plant growth. * * *

The physical nature of soil structure is more important to plant life than the chemical composition of the soils due to the relation between soil texture and water-content.

In discussing the relation between the crop centers and centers of natural vegetation, the author says:

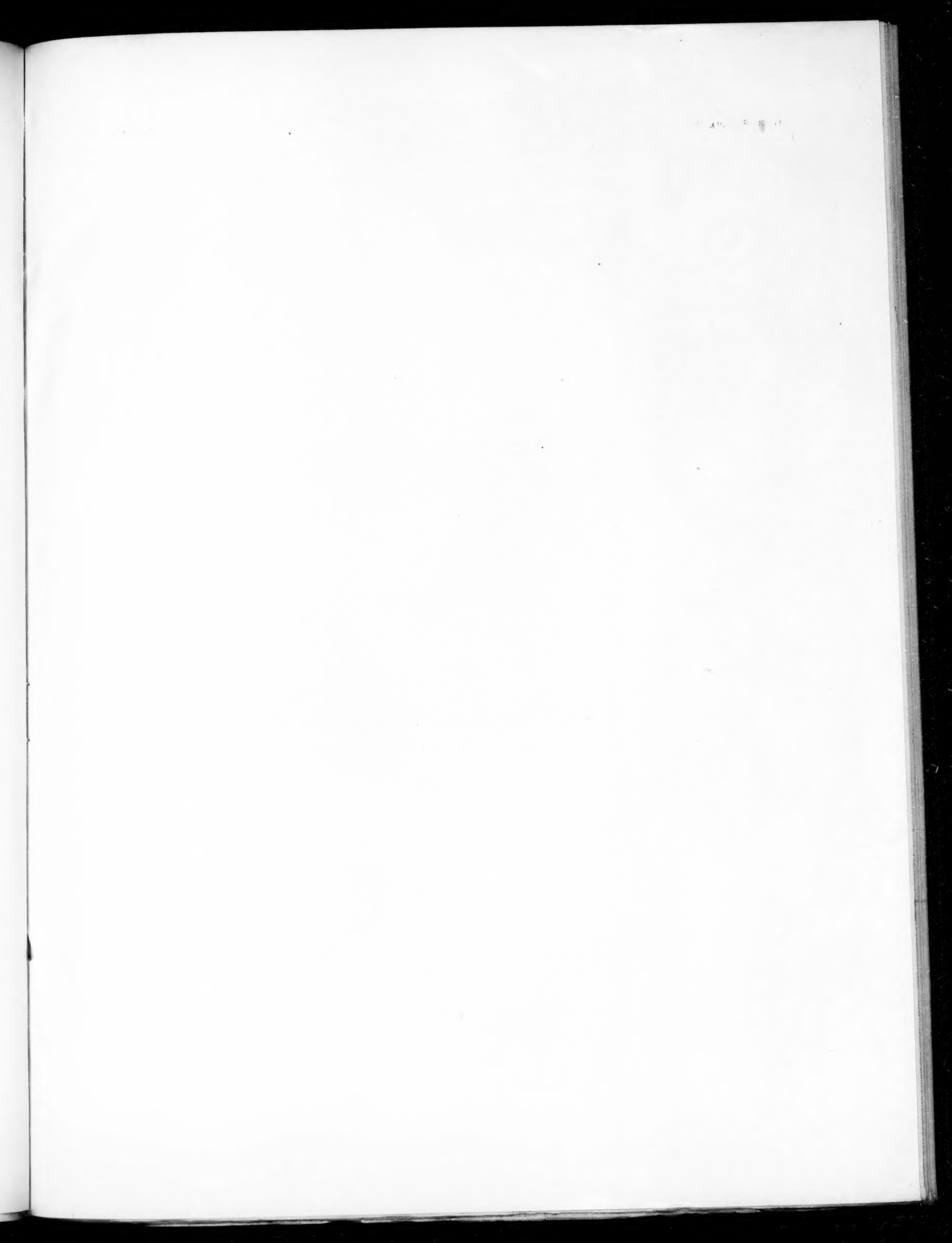
The corn and wheat belts agree with the deciduous forest and the prairie centers in the United States. * * *

Three sets of factors are operating in combination to establish this region as the center for the production of our great cereals. These factors may be grouped as climatic, edaphic, and economic.

By reason of the hot, almost tropical summers with the relative humidity rather high and the annual rainfall sufficient for the growth of the plant, the entire area from Ohio to central Nebraska on the north and southward to the Gulf of Mexico is suited to corn production. * * *

The climatic factor in Indiana and Ohio is suited to the profitable production of corn, but production centers in Illinois for edaphic reasons. * * *

In the United States wheat production centers on the 60 per cent rainfall-evaporation ratio line. This means that the center of wheat production lies west of the best corn lands, although on many farms throughout the prairie and deciduous forest climaxes both wheat and corn are usually grown, if rotations are practiced. In the matter of growing wheat in regions too dry for corn, the United States is not an exception to the rule. The great wheat-producing regions all over the world are level plains with a cool, rather dry climate. It is known that wheat, particularly winter wheat, yields larger crops in the more humid sections, yet in normal times other crops can be grown in the humid parts of the United States with greater profit than wheat. It is competition with these crops that drives wheat to the plains. * * *



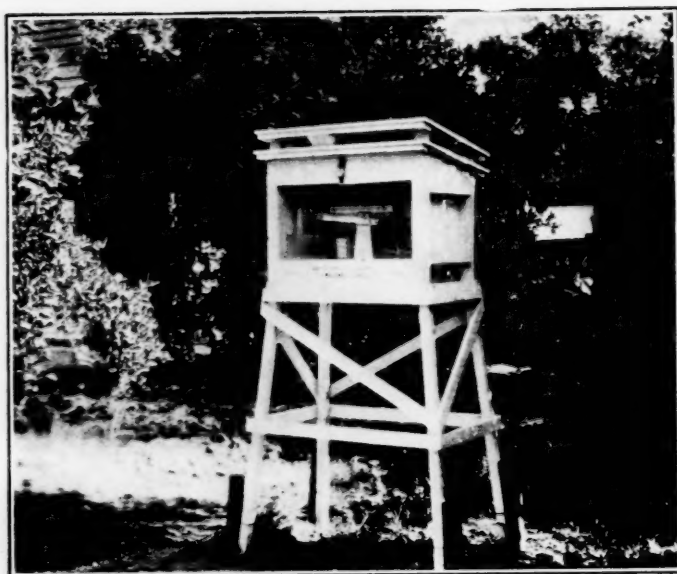


FIG. 1.—Special instrument shelter at the Pomona Cooperative Weather Bureau station.

An inspection of the spring wheat chart shows production to center on the northern extension of the 60 per cent line where all the evaporation lines are rather close together and nearly parallel. Ecologically, spring wheat could as well be grouped with the crops of the north-eastern center, but geographically it belongs with the prairie climax. Edaphic considerations, then, rather than climatic, locate the area of spring wheat production. * * *

Oats center slightly north of the corn belt. Climatically, the center of production would be expected much farther northward. Edaphic reasons, and the convenience of a spring-sown crop rather than a fall-sown one to follow corn in the rotation now largely in practice in the corn belt, push the center somewhat to the south. * * *

The region south and east of the 100 per cent rainfall-evaporation ratio line is ecologically known as the southeastern evergreen center. While the rainfall throughout this part of the country is greater than it is northward, higher temperatures cause much more rapid evaporation. The physiological water requirement is higher. * * *

Cotton is the principal crop plant of this region. Eastward the extension of the southern Appalachians makes too rough a topography for the production of a cultivated crop. Temperature is the limiting factor of production northward; moisture is the limiting factor westward beyond central Texas.

Other comparisons of interest are that the fodder crops are important in New York and New England because "the lower temperatures make cereal production less profitable;" "the center of the white potato production in the Northeast bears a fairly close relation to the north-eastern evergreen center;" "the cultivated plants of the plains climax must be grown under the best known methods for saving and utilizing all the water that can be captured by the soil and under irrigation;" and "the establishment of alfalfa as an important crop at about the one hundredth meridian, where the rainfall is only six-tenths of the evaporation."

In his discussion of animal centers the writer points out that "back of the interrelations between plants and animals is the relation of both to the physical factors of their environment." "Beef cattle and swine are found centering in and slightly west of the corn belt;" "the greatest production of horses is in the region just north of the corn belt," which is also the present center of oats production.

The summary is quoted below in full:

The crop centers of the United States agree with the biotic centers. In detail this means that the corn and winter wheat belts correspond to the deciduous central forest and the prairie climaxes, the tame hay and pasture region to the northeastern evergreen forest, the cotton belt to the southeastern evergreen forest, and so on. The rainfall-evaporation ratio map is useful for the demarcation of these centers because in it are included four factors of climate, namely, relative humidity, temperature of the evaporating surface, and wind velocity as the divisor and precipitation as the dividend. These four factors are of profound importance to plant growth.

Edaphic factors frequently determine the distribution of the cultivated plants. Edaphic and climatic factors, although they may be independent of one another in their operation, sometimes cause the same agricultural practices to be employed. Economic factors modify the influence of climate and soils.

A fundamental difference between crop plants and the natural vegetation is seen when plants are found beyond their usual centers. The crops are found on the best soils only, since that is their sole chance to compete with other crops for profit. Plant invaders of the indigenous vegetation migration from their centers can offer competition in the poorest habitats only. In the better habitats the plants belonging to the center are little influenced by invaders.

In addition to the exotic crops being given the best fields, further soil modifications are usually introduced. In the extreme cases, climatic as well as soil modifications are practiced. Field plants are then grown on a comparatively large scale under glass or cloth shelter.

The domesticated animals are grouped about the centers of production of those crops upon which they are most dependent.

The methods used in studying plant succession have been used here. It is in this field of research that an accurate interpretation of conditions as consequences of the operation of physical forces of the past and present has been made. Migration, including invasion and competition, the latter implying dominance, are the direct results of interaction of climate and soils upon vegetation.

LAWN SPRINKLER AND THERMOGRAPH.

By WILLIAM G. REED, Meteorologist.

[Dated: Pomona, Cal., December 5, 1917.]

In connection with the possible effect of irrigation on the local climate the traces from the one-day thermograph

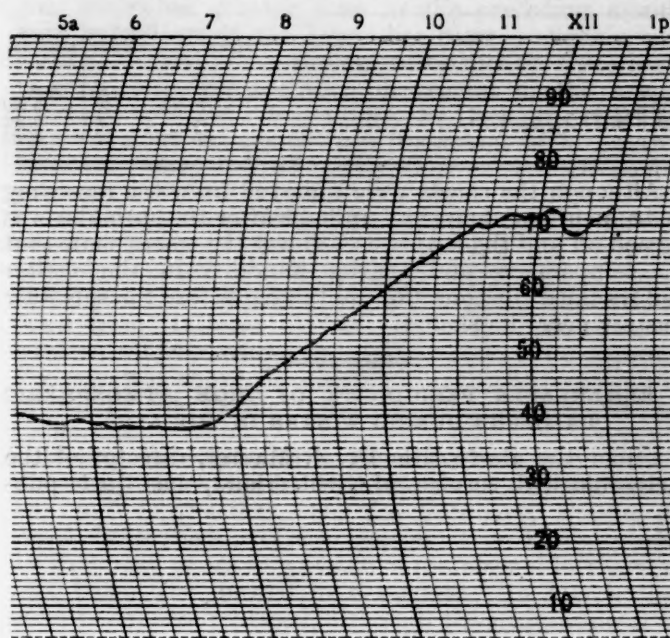


FIG. 2.—Thermogram for the City Hall lawn, Pomona, Cal., Dec. 5, 1917. Lawn sprinkler near shelter about 12:10 p. m.

and hygrograph exposed in a 1917-pattern shelter (fig. 1) on the lawn of the City Hall at Pomona, Cal., may be of interest (see figs. 2 and 3). The curves show nothing

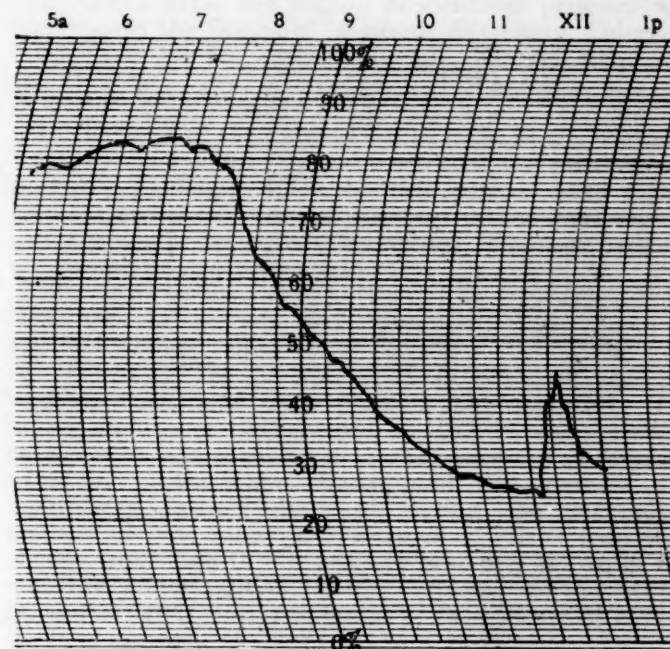


FIG. 3.—Hygrogram for the City Hall lawn, Pomona, Cal., Dec. 5, 1917. Lawn sprinkler near shelter about 12:10 p. m.

unusual until about 12:10 p. m., when the temperature fell sharply about 4 degrees in 15 minutes and the relative humidity rose 20 per cent in the same time or a

little longer. These changes appear to be the result of turning on a lawn sprinkler near the shelter.

The following table shows the effect upon the air $4\frac{1}{2}$ feet above the ground as a result of the action of a sprinkler throwing water to a height of 2 or 3 feet and continued long enough to soak the turf under the shelter.

Time.	Air temperature.	Relative humidity.	Vapor pressure.
	<i>° F.</i>	<i>Per cent.</i>	<i>Inch.</i>
12:10 p. m.	73.0	25	0.202
12:20 p. m.	69.0	40	0.283
12:30 p. m.	68.5	45	0.313

Although the sheets were removed from the recording instruments in about half an hour after the sprinkler was turned off and the lawn was still wet the traces show that the temperature and relative humidity in the shelter had resumed the conditions obtaining before the sprinkler was set near the shelter.

A REMARKABLE PERIODICITY OF HIGH ATMOSPHERIC PRESSURE DURING WINTER IN THE ALPS.

Under the above title Dr. J. Maurer, director of the meteorological service of Switzerland, has just pub-

lished¹ an account of a weather periodicity that promises to be of unusual interest and value.

It appears from this study that in Switzerland, according to the records of the past 50 years at Basil, Zurich, Geneva, and Lugano, the sums of the monthly pressure departures for November, December, and January, show a distinct periodicity of 8 years, with a range from maximum to minimum of, roughly, 20 millimeters. Additional Geneva records back to 1836, and Basil records to 1816, show that this 8-year period has persisted now with remarkable regularity for more than a century, and perhaps therefore very much longer.

The smoothed (apparently freely drawn) graph of the actual data is all that was used in arriving at the above conclusion. Indeed the maxima and minima are so pronounced, and so evenly spaced, as to make unnecessary, it is claimed, any special analysis, beyond mere inspection.

No cause for this special period is suggested, nor is obvious. But if indeed true it can hardly be an isolated phenomenon, and therefore should stimulate similar studies of pressure data in other parts of the world.—
W. J. H.

¹ Archives des Sciences Physiques et Naturelles, Mai, 1918.

SECTION III. FORECASTS.

FORECASTS AND WARNINGS, JUNE, 1918.

By ALFRED J. HENRY, Supervising Forecaster.

(Date: Weather Bureau, Washington, July 22, 1918.)

PRESSURE OVER THE PACIFIC AND ALASKA.

Pressure at Honolulu has been uniformly below the normal since the 1st of April. At Midway Island also it has been below the normal except for short periods. Thus, in June, pressure at Midway was above normal from the 8th to the 12th and from the 21st to the 23d.

Pressure in Alaska during June was mostly above the normal except for two short periods of low pressure corresponding roughly to the periods of high pressure at Midway Island, given above. The low pressure at Honolulu was the subject of some comment by the present writer in the April REVIEW 46:182. Since that time he has had an opportunity to examine the previous records of monthly mean pressure at Honolulu and to attempt to correlate them with weather in the United States. The attempt was not successful in reaching definite conclusions or, indeed, in establishing any relation between the pressure at Honolulu and subsequent weather in the United States. A record of 27 years of monthly mean pressures is available for Honolulu, and it would seem that a correlation of the monthly departures from the normal with similar data for points in the United States would yield useful data. Dot charts have been made to show the relation between April departures at Honolulu and departures for the same month at several points in the United States. Similar charts have been made also for April at Honolulu and the subsequent months of May, June, and July in the United States in the expectation that perhaps a drifting eastward of the pressure abnormalities might appear. There was much scattering on the dot charts and there did not seem to be any definite relation between the two events.

Arctowski¹ has shown that pressure abnormalities in the United States progress from East to West. His studies, however, refer to annual abnormalities.

In order to determine whether the monthly abnormalities of pressure show a similar progression, I have charted them for the eight months, October, 1917, to May, 1918. The monthly departures from the normal pressure are regularly published in Table 1 of the MONTHLY WEATHER REVIEW and these values have been used. The chart for October, 1917, shows that pressure for that month was below the normal in the Lake region and thence eastward to the Atlantic, including the Ohio Valley; and that it was above normal in the South and West with the peak of the excess in the northern Rocky Mountain and Plateau regions and the States of Washington and Oregon. In the succeeding month of November, pressure was everywhere above normal except along the New England coast and at Hatteras, N. C. The peak of the excess was found in the upper Lake region—a distinct eastward movement as compared with October. It is interesting to note that pressure was above the average in November in those districts in which the excess in October was most marked. In the third month of the comparison, December, 1917, the peak of the HIGH was in Minnesota and North Dakota with a second peak in upper Michigan and the excess

was somewhat greater than in the preceding months. While the peak of the December HIGH is slightly westward of its position in the preceding month, there is still a very noticeable eastward movement of the area of excess of pressure. As a whole, the December chart also shows a small area, including Wyoming, Idaho, western Montana, eastern Washington, and eastern Oregon, of pressure below the normal.

In the January, 1918, chart this region of deficient pressure has apparently spread eastward and southward to include practically the entire country; but, curiously, the districts of greatest deficit are along the Atlantic coast from Hatteras to Eastport, rather than over the western interior where naturally it would be expected. Pressure was above the normal for the fourth consecutive month in the Pacific Coast States except in southern California.

During February, 1918, the distribution of pressure abnormalities changed. Hitherto the line of zero change had a N-S direction. On the February, March, and April charts the line of zero change has an E-W direction. In February pressure was above the normal in the north and below the normal in the south. In March these conditions were reversed, although the magnitude of the departures was not great in any part of the country. In April the seesaw continued. In this month pressure in the northern part of the United States was above the normal and in the southern part below the normal, although, as before, the magnitude of the abnormalities was not great.

In May, 1918, the region of deficient pressure was confined to the States of Montana, Wyoming, Colorado, Utah, New Mexico, eastern Nevada, Kansas, Nebraska, the Dakotas, Iowa, Minnesota, and Wisconsin, and the region of excess pressure to the remainder of the country with the peak of the excess (+0.15 inch) in the southern Appalachian region. Thus we see that the pressure abnormalities computed for monthly periods have a progressive movement toward the east in the cold season, and during the spring months appear to seesaw between a north and a south direction.

Of course, definite results can not be established from eight months' records, but enough has been shown to warrant further effort along the same lines. The goal is, of course, the possibility of determining seasonal weather conditions from pressure abnormalities. The unseasonable cold of the winter of 1917-18 was preceded, as we have just seen, by a marked increase in pressure over the northwestern States, and this increase was maintained farther eastward during the succeeding months of November and December. It is true that change from high to low pressure was first shown in the monthly abnormalities for the extreme northwest for December, 1917, but the January, 1918, chart of abnormalities conveys the very distinct impression that the development of low pressure over the western North Atlantic was independent of the depression of the barometer in the Northwest of the preceding month. The apparent explanation is that LOWS, after reaching the Atlantic coast, increased in intensity and thus caused a greater deficit in pressure over the coast regions than at points to the westward.

Comparing the charts of abnormal pressure distribution with chart IV of the MONTHLY WEATHER REVIEW,

¹ Bulletin American Geographical Soc 42: 273, 1910.

"Departures of mean temperature from the normal," we note the following:

October, 1917: The region of greatest negative temperature departure is considerably to the eastward of the corresponding area of greatest positive pressure departure.

November, 1917: The area of greatest positive temperature departure (15° F.) is almost coincident with the area of greatest positive pressure departure, whereas the area of negative temperature departure coincides with a region of small positive pressure departures. The evidence of this month is contrary to the idea that positive pressure departures are coincident with negative temperature departures, but in the succeeding month of December, 1917, there is a complete reversal of the November conditions; pressure was almost everywhere above the normal and temperature east of the Rocky Mountains was below the normal. West of the Rockies, however, both pressure and temperature were above the normal.

In January, 1918, the pressure departures were practically the reverse of those which obtained in December, 1917, but the temperature abnormalities were almost identical with those of the previous month. Further comparison seems to show that the relation between abnormalities of temperature and pressure is not a direct and simple one.

The current month was characterized by low pressure in the southern part of the United States, the Gulf and Caribbean regions, and the western portion of the North Atlantic.

Temperature was exceptionally high, mainly in the Southwest, and west of the Rocky Mountains, although high temperatures also prevailed in the middle Mississippi and lower Ohio valleys and along the Gulf coast. In northeastern districts the month was relatively cool and dry and in general the precipitation was below the normal.

PRESSURE ABNORMALITIES AND SUNSPOT MINIMA.

Returning now to the subject of Pressure Abnormalities it is to be noted that an inspection of the numerical values of monthly pressure departures at Honolulu for the 22 years, 1895-1917, shows a very striking period of deficient pressure centered about the sunspot minima of 1901.7. The April monthly departures for the period are as follows:

Month.	Departure.
April, 1899.....	-0.06
April, 1900.....	-0.07
April, 1901.....	-0.07
April, 1902.....	-0.05
April, 1903.....	-0.07

Departures of equal magnitude were experienced in practically every month of the four years 1899-1902, the greatest departure in any month being -0.18 in February, 1901, a month of severe weather in Hawaii with snow in the mountains.

Negative departures in the monthly mean pressure at stations in the southern part of the United States were also recorded during the four years above mentioned; but the magnitude of the departure was not so great, nor were the departures so continuous from month to month, as at Honolulu.

The period covered by the negative departures at stations in the United States varied also from point to point.

Thus, it began at San Diego, Cal., in 1897, two years before it began at Honolulu; while at Key West, Fla., the beginning was deferred to 1902—a year after the epoch of minimum spottedness, and three years after diminished pressure was manifest at Honolulu.

Passing now to the next epoch of sunspot minima, viz, 1913-14, it is to be noted that while the tendency is toward negative pressure departures, both their magnitude and uniformity are much less than during the epoch 1901.7.

Daily reports received at the Washington Office in June 1918, showed the existence of abnormally low pressure over the western Caribbean region as well as along the Gulf Coast and over Florida. By reference to reports for April and May, 1918, it is found that pressure was also low in these months; therefore what was at first supposed to be a local depression of the barometer at Honolulu was really an extensive depression of the barometer probably extending in an E/W direction over at least a quarter of the earth's circumference.

THE WEATHER OF THE MONTH.

It is difficult to define just what definite control, if any, was exercised by the diminished pressure in subtropical regions as indicated in the preceding paragraph. We can, however, point out the abnormal features of the weather in the United States, leaving to the future any adjustment as to cause and effect that may be possible. As a whole the month was dry except in the State of Iowa and in a limited region adjacent thereto. Showers fell in Iowa almost daily, seemingly without much regard to the pressure distribution except that the border zone between low pressure to the southwest and higher pressure to the northeast passed through that State. The temperature distribution was marked by high values in the Rocky Mountain and Plateau Regions and the southwest, including in the last expression Oklahoma, Texas, New Mexico, Arizona, and Nevada. At the same time the temperature in northeastern districts was unseasonably low the greater part of the month. During the second decade the highest June temperatures of record were registered at a number of stations in the southwest, some of which have a series of observations extending upward of 40 years. Unusually high temperatures were also registered along the Gulf coast, in Missouri, Iowa, the lower Ohio valley, and the northern Rocky Mountain Region.

In a general way, the run of the LOWS in June was along the northern boundary, but almost without exception they were lacking in intensity and showed a tendency to move toward Hudson Bay. The HIGHS, on the contrary, were unusually vigorous for the season, and several of them passed entirely across the country. The place of origin seems to have been about equally divided between the North Pacific and the interior of the Canadian northwest. It seems reasonable to attribute the unusual activity of the HIGHS to existing low pressure both in extratropical regions and over the western North Atlantic off the South Atlantic coast.

HIGHS.

Nine principal and one secondary HIGH have been plotted, of which four apparently originated over the Pacific off the British Columbia northwest. In only three of these did the barometer level reach and pass above 30.30 inches. HIGH No. 8, originating in Alberta on the 20th, was attended by frost in the lowlands of Michigan and Indiana on the morning of the 23d. This HIGH attained its greatest intensity in the morning of

the 21st over northern Manitoba. After passing within the United States it diminished in intensity, and on the 24th had practically disappeared. Frost did not occur in other sections of the Northwest, but in the States named the sky cleared and the wind fell on the night of the 22-23d, thus realizing ideal conditions for the occurrence of frost even though the barometric conditions were not decisive.

LOWS.

Ten primary and three secondary LOWS have been plotted. The great majority of the primary LOWS were of the Alberta type. Low No. 1, while grouped with the primary LOWS, persisted but 36 hours. Its influence was appreciable over eastern districts, although the surface pressure gave no indication of a cyclonic circulation.

The movement of LOW No. 9 is uncertain over that portion of its path represented by a dashed line. Pressure had been low over the Southwest for several days before the LOW in question began a movement toward the northeast. The immediate cause of its movement appears to have been the southward sweep of HIGH No. 9.

STORM WARNINGS.

Storm warnings were issued for the Great Lakes on the 1st, 11th, and 28th. The warnings on the last-named date were only partially verified.

Storm warnings were issued for the Atlantic coast, Delaware Breakwater to Eastport, on three occasions, viz, on the 11th, 21st, and 26th. On the 11th a deep depression passing down the St. Lawrence Valley was the cause of fresh to strong westerly winds along the coast on the 12th. On the 21st it was anticipated that a depression over the Great Lakes would develop in intensity as it approached the coast. Strong southerly winds were experienced on the coast of Southern New England on the 22d and on the Maine coast on the morning of the 23d.

The third display of storm warnings on the Atlantic coast was occasioned by the presence of a moderate disturbance over Cape Hatteras the morning of the 26th. This disturbance caused moderate easterly gales off the Virginia coast, but there was no wind of consequence along the New Jersey coast since the storm moved off to sea instead of northeastward along the coast.

FROST WARNINGS.

Warnings of light frost were issued for the cranberry bogs of New Jersey on the 8th, 15th, 19th, 20th, and 23d. The warnings of the 8th and 20th were followed by light frost in the bogs; that of the 15th was followed by a minimum temperature of 28°, and those of the 19th and 23d were failures. A general failure of light frost warnings for the Middle Atlantic and New England States on the 23d is to be noted. The temperature in these States on the morning of that date was 15 to 20° below the seasonal average and the weather was cloudy with anticyclone conditions advancing from the west. The failure of the anticyclone to continue in its eastward movement seems to be the explanation of the failure in the frost forecasts.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—No warnings of a general character were issued at any time during the month, special advices being limited to local frost warnings.

On June 6 warnings of frost were sent to the cranberry marshes of Wisconsin, and a minimum of 27° was reported the next morning on the bog at Beaver Brook. The temperature at the other stations did not fall to freezing. Moreover, light frost occurred without warnings at Beaver Brook on June 22 and at Berlin on June 23, but the temperature was not low enough to cause any damage.—*H. J. Cox, District Forecaster.*

New Orleans, La., forecast district.—Warm weather for June prevailed generally over the district, and temperature changes were, as a rule, slight. Precipitation was unevenly distributed, being above the normal over the northern, and below the normal in most localities over the southern portion of the district.

No storm warnings were issued and no general storm occurred during the month.—*I. M. Cline, District Forecaster.*

Denver, Colo., forecast district.—The warnings issued were confined to frost warnings in high districts in northern Utah on the 1st and advices of moderate to fresh and possibly strong winds for portions of New Mexico, Arizona and Utah on a few dates in the latter part of the month. At regular stations fresh to strong winds occurred as follows: At El Paso on the 21st, 28 miles per hour from the southeast; at Salt Lake City on the 15th, 36 miles from the southwest. Advices of fresh to strong southerly winds were issued for both of these dates.—*Frederick W. Brist, Assistant Forecaster.*

San Francisco forecast district.—June, 1918, was unusually quiet in the San Francisco District. Temperatures averaged unusually high, except along the immediate coast. Rainfall in portions of Nevada and extreme southern California was slightly above normal, but in the principal agricultural sections of the district there was a marked deficiency. No storm, fire-weather, or other special warnings were issued, nor were they needed. The weather charts on June 8, 9, 10, 11, 12, and 13 illustrate the successive steps that take place in the formation of an elongated trough-shaped barometric depression, which originates over southern California and later projects northward and joins a low-pressure area of slight energy over British Columbia. During the early days of the formation temperatures gradually increase, and on the third or fourth day the trough-shaped barometric depression breaks up into several small low-pressure areas, which are characteristic of an unstable atmospheric condition. During the evolution of the formation sporadic electrical storms occur in the mountain sections of the district, which on successive days become more and more numerous. They reach their maximum when the trough-shaped depression breaks up into eddies, and a day or two afterward the entire disturbance advances eastward and conditions in this district become normal. The electrical storms attending the phenomenon just described caused numerous forest fires in this district during the current month, most of which were easily extinguished; but some got beyond control, and were causing considerable trouble at the end of the month. Fortunately no very high winds occurred, and the fires had not become large enough to cause serious doubts as to their ultimate control should the weather continue quiet. On account of the great deficiency in precipitation and the general excess in temperature since the first of the year, the forest undergrowth is unusually dry, and with normal conditions during July and August there will be many unpreventable fires started by lightning. Therefore every precautionary measure possible should be taken against the starting of preventable fires.—*E. A. Beals, District Forecaster.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, JUNE, 1918.

By ALFRED J. HENRY, Meteorologist in Charge.

[Dated: River and Flood Division, July 30, 1918.]

June rains, as a rule, were not sufficient in quantity nor general enough in distribution to produce serious floods in the larger streams of the United States, except in the Des Moines River of Iowa and in the Mississippi in the stretch from Keokuk, Iowa, to Louisiana, Mo.

The flooding in this stretch was due to heavy rains during the latter part of May and again on June 4-5 throughout central Iowa, especially in the watershed of the Boone—a tributary of the Des Moines River—where the total 24-hour fall on the morning of the 4th was close to 5 inches. Flood stages were reached at Boone, Iowa, on the 4th, and at Ottumwa on the 7th; and this rise out of the Des Moines caused flood stages to be reached in the Mississippi at Keokuk, Iowa, and Warsaw, Ill., on the 12th. Other Iowa rivers also reached high stages as a result of very general and almost continuous showers during the periods designated above.

The Mississippi immediately south of Keokuk began to overflow the unprotected lands on the 9th, and these lands at the highest stage were covered to a depth of about 2 feet. Lands protected by small levees were not overflowed. The official in charge at Keokuk, Iowa, Mr. F. Z. Gosewisch, estimates that between 5,000 and 6,000 acres, mostly planted to corn, were overflowed. Eight hundred acres planted to tomatoes by a local canning company were also overflowed.

The loss in the Keokuk district was confined to seed and the labor of replanting.

In the Hannibal district, from Warsaw, Ill., to Louisiana, Mo., the Mississippi was in flood from the 10th to the 17th, except at Hannibal, where flood stages continued from the 8th to the 20th, with a crest stage of 17.8 feet on the 13th (flood stage 13 feet). In this district the breaking of a levee on June 13 was the cause of a loss to the levee and pumping station of approximately \$90,000.

The Mississippi reached bank-full stages between Louisiana, Mo., and Grafton, Ill., and the flood ended in that stretch of the river. There was practically no damage to corn in the St. Louis district.

Upper Mississippi—Dubuque district.—There was a sharp rise in the Mississippi in the Dubuque district, due to heavy rains on the watersheds of the Wisconsin, Black, and Chippewa Rivers; and while flood stage was not reached in the main stream, yet the overflow from the mouth of the Galena River to La Crosse, Wis., especially in the neighborhood of Cassville, Wis., and along Turkey River of Iowa, caused a loss of prospective crops on 5,000 acres, as estimated by Mr. J. H. Spencer, in charge of the Dubuque, Iowa, river district. Mr. Spencer states that hundreds of acres in the lowlands along the river had been planted to potatoes, other truck crops, and corn, and many other hundreds of acres had been prepared for late crops. All planting in the lowlands naturally ceased with the coming of the high water.

Some damage to growing crops along the south fork of the Solomon River in the neighborhood of Beloit, Kans., is reported.

Rivers of Central Rocky Mountain region.—Floods due to the melting of snow in the higher levels of Colorado

occurred in the second decade of the month and these tributary floods reached the lower Colorado at Topock, Ariz., on the 20th and Yuma, Ariz., on the 26th, both floods having been accurately announced by District Forecaster Brandenburg 9 and 12 days, respectively, in advance.

Flood in Columbia River.—The annual flood in the Columbia River due to melting snow was in progress in the lower reaches of the river as the month closed. Further report on this flood will be made in a subsequent number of this REVIEW.

Summary of lands overflowed.

District.	Acres overflowed.	Estimated loss.
MISSISSIPPI RIVER.		
Keokuk, Iowa.....	5,500	Nominal.
Hannibal, Mo.....	8,500	Cost of seed and labor replanting.
Dubuque, Iowa.....	5,000	Do.
RIO GRANDE.		
Houston, Tex.*.....	?	Mostly cost of seed and labor of replanting.

* From May floods on lower Rio Grande not previously reported.

TABLE I.—Flood stages in the Mississippi River drainage during June, 1918.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
<i>Mississippi:</i>	<i>Feet.</i>			<i>Feet.</i>	
Keokuk, Iowa.....	14	10	15	16.8	12
Warsaw, Ill.....	17	10	15	19.5	12-13
Quincy, Ill.....	14	10	17	17.7	13
Hannibal, Mo.....	13	8	20	17.8	13
Louisiana, Mo.....	12	(†)	1	12.1	* 31
Do.....	12	10	19	15.3	14
Grafton, Ill.....	18			17.4	16-17
<i>Big Pigeon:</i>					
Newport, Tenn.....	6	21	21	8.0	21
<i>Holston (North Fork):</i>					
Mendota, Va.....	8	26	26	8.3	26
<i>Wisconsin:</i>					
Knowlton, Wis.....	12			11.2	2
Portage, Wis.....	11			10.2	2
<i>Des Moines:</i>					
Boone, Iowa.....	17	4	5	23.2	5
Des Moines, Iowa.....	17			16.5	7
Ottumwa, Iowa.....	10	7	13	14.0	10
		25	25	11.9	25
<i>Illinois:</i>					
Peru, Ill.....	14			13.2	2
Henry, Ill.....	7	(†)	5	7.5	2
Beardstown, Ill.....	12	(†)	3	12.6	1-2
Pearl, Ill.....	12			10.8	16
<i>St. Francis:</i>					
Marked Tree, Ark.....	17			16.6	1-10
<i>Missouri:</i>					
Brunswick, Mo.....	10	9	9	10.3	9
Running Water, S. Dak.....	16			14.7	25-27
Blair, Nebr.....	16			15.1	28-29
<i>Grand:</i>					
Chillicothe, Mo.....	18	(†)	2	21.2	1
<i>Solomon:</i>					
Beloit, Kans.....	16	1	4	26.5	3
<i>North Canadian:</i>					
Canton, Okla.....	3	1	2	3.6	1
<i>White:</i>					
Georgetown, Ark.....	22	(†)	3	28.3	* 20
Clarendon, Ark.....	30			29.9	1
<i>Black:</i>					
Black Rock, Ark.....	14	(†)	3	25.7	* 14
<i>Cache:</i>					
Jelks, Ark.....	9	(†)	4	9.8	* 24-25

† Continued from May.

* May.

TABLE II.—Flood stages in Colorado and West Gulf drainages during June, 1918.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
<i>Colorado:</i>	<i>Feet.</i>			<i>Feet.</i>	
Topock, Ariz.....	14	16	25	17.0	20
Yuma, Ariz.....	25			24.7	26
<i>Grand:</i>					
State Bridge, Colo.....	9	11	24	10.7	15
Grand Junction, Colo.....	11	11	17	11.9	15
<i>Roaring Fork:</i>					
Carbondale, Colo.....	6	9	18	7.5	13
Do.....		22	23	6.0	22-23
<i>Eagle:</i>					
Eagle, Colo.....	5	10	18	6.0	12-14
Do.....		21	25	5.2	22
<i>Gunnison:</i>					
Delta, Col.....	9			8.7	12-13
<i>Gunnison (North Fork):</i>					
Paonia, Colo.....	8	11	12	8.0	11-12
Do.....		14	14	8.0	14
<i>Green:</i>					
Green River, Wyo.....	9	10	29	12.5	20
Elgin, Utah.....	13	24	24	13.0	24
WEST GULF.					
<i>Rio Grande:</i>					
San Marcial, N. Mex.....	14			12.7	12
<i>Trinity:</i>					
Dallas, Tex.....	25	10	10	26.5	10

TABLE III.—Flood stages in Pacific drainage during June, 1918.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
<i>Kings:</i>	<i>Feet.</i>			<i>Feet.</i>	
Piedra, Cal.....	12	12	14	12.0	12-14
<i>Columbia:</i>					
Marcus, Wash.....	24	12	**	31.2	25-27
Wenatchee, Wash.....	40	23	28	40.5	24-27
Vancouver, Wash.....	15	12	**	20.1	26
<i>Pend d'Oreille:</i>					
Newport, Wash.....	16	18	28	17.0	21-23
<i>Kootenai:</i>					
Bonniers Ferry, Idaho.....	26	15	17	26.6	16
<i>Clearwater:</i>					
Kamiah, Idaho.....	14			13.3	10-11
<i>Willamette:</i>					
Portland, Oreg.....	15	12	**	19.2	25-27

** Continued into July.

MEAN LAKE LEVELS DURING JUNE, 1918.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., July 8, 1918.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during June, 1918:	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
Above mean sea level at New York.....	602.10	581.97	572.53	247.01
Above or below—				
Mean stage of May, 1918.....	+0.36	+0.33	+0.33	—0.12
Mean stage of June, 1917.....	—0.41	+0.43	—1.00	+0.03
Average stage for June, last 10 years.....	—0.16	+1.19	—0.42	—0.02
Highest recorded June stage.....	—1.33	—1.63	—1.99	—1.62
Lowest recorded June stage.....	+0.86	+2.07	+0.96	+2.12
Average relation of the June level to—				
May level.....	+0.3	+0.3	+0.2	+0.2
July level.....	—0.2	+0.1	—0.1	+0.1

* Lake St. Clair's level: In June, 575.89 feet.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR JUNE, 1918.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Aug. 1, 1918.]

TABLE 1.—Noninstrumental earthquake reports, June, 1918.

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Foré.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
CALIFORNIA.										
1918.	H. m.		° ' "	° ' "			M. s.			
June 3	16 05	Bishop Creek.....	37 23	118 23	3-5	2	15	Rumbling.....	Abrupt bumps and trembling...	E. M. Nordyke, Wm. Barth, E. L. Herzinger.
5	4 33	Calexico.....	32 41	115 30	3	1	01	Faint.....	Rumbling, single bump, NE-SW.	H. M. Rouse.
6	22 32	Beaumont.....	33 55	117 00	4	1	15	None.....	Rapid rocking, NE-SW.	F. D. Campbell.
		Corona.....	33 53	117 34	3	2		None.....		Thomas C. Sias.
		Escondido.....	33 07	117 06	4	1		None.....		A. R. Moon.
		Hemet.....	33 44	116 58	5	2	04	Rumbling.....	Gradual twisting, S-E.	C. E. McManigal.
		Indio.....	33 43	116 13	5	1		Rumbling.....	Gradual rocking and trembling.	Fred N. Johnson.
		Riverside.....	33 59	117 23	4	1		None.....		John H. D. Cox.
		San Bernardino.....	34 06	117 18	4	1		None.....		Mrs. Sarah W. Frantz.
		San Diego.....	32 43	117 10	2	1	02	None.....	Rapid trembling, N-S.	H. F. Alciatore.
		San Diego (Camp Kearny, 15 miles north).	32 56	117 10	2	1		None.....		San Francisco Examiner.
		Warner Springs.....	33 17	116 39	4-5	1	30	None.....		J. A. Ream.
12	8 47	Calexico.....	32 41	115 30	4	1	05	None.....	Gradual rocking N-S.	H. M. Rouse.
	14 19	Calexico.....	32 41	115 30	3	1	01	Loud.....	Rumbling, rapid trembling, E-W.	H. M. Rouse.
14	10 24	Hemet.....	33 44	116 58	5	2	06	Loud.....	Abrupt bumping, NE.	C. E. McManigal.
16	22 10	Hemet.....	33 44	116 58	3	1	03	Rumbling.....	Abrupt bumping, NE.	C. E. McManigal.
20	12 10	Hemet.....	33 44	116 58	3	1	03	Loud.....	Abrupt bumping, NE.	C. E. McManigal.
21	19 37	Hemet.....	33 44	116 58	3	1	03	Faint.....	Abrupt bumping, NE.	C. E. McManigal.
22	5 52?	Barrett (6 miles north)...	32 42	116 41	5	1	03	Faint.....	Abrupt bumping, N.	L. Watts.
	6 00?	Mesa Grande.....	33 10	116 46	3	1	01	Loud.....	Rumble from west 4-5 seconds before shocks, then an abrupt bump, W-E; rumble ended in 9 seconds, in E.	Edward H. Davis.
29	5 57?	Warner Springs.....	33 17	116 39	3-4	1	30	None.....	Gradual rocking and trembling.	J. A. Ream.
	16 17	Salinas.....	36 41	121 39	4	1	02	None.....	Abrupt bumping, SE-NW.	Dr. Earl D. Eddy.
		Spreckels.....	36 38	121 36	3	1	01	None.....	Gradual rocking, N-S.	Dr. M. A. Klein.
TENNESSEE.										
22	1 00?	Clinton.....	36 05	84 08	4	1	05	Rumbling.....	Gradual trembling, NE.	J. E. Weaver.
		Kingston.....	35 52	84 32	3	1	03	Rumbling.....	Rapid trembling, SW.	Sallie Littleton.
		Knoxville.....	35 55	83 58	3	3	09	Faint.....	Rumbling, rapid rocking.	J. F. Voorhees.
		Lenoir City.....	35 47	84 17	6			Loud.....	Rumbling like a pair of heavy trucks rolling over the floor, gradual trembling.	W. N. Lacy.
		Loudon.....	35 44	84 21	5	1	15	Loud.....	Like rumbling thunder; abrupt bump, then rapid trembling, NW.	Robert W. Clark.
		McGhee.....	35 35	84 14	5?	1	1 00	Rumbling.....	Gradual onset with bumping, NE.	John O. Woods.
		Philadelphia.....	35 41	84 25	5	1	05	Faint.....	Abrupt bump, then gradual rocking and trembling, NE.	Will C. Cannon.
		Sweetwater.....	35 36	84 29	5	2	04	None.....	Abrupt trembling, N-S.	Hulah C. Browder.
WASHINGTON.										
21	5 47	Longmire.....	46 46	121 50	5	1	02	Faint.....	Rumbling, gradual swaying, N-S.	John B. Flett.

TABLE 2.—*Instrumental reports, June, 1918.*

(Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.)

[For significance of symbols see REVIEW for January, 1918, p. 34.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude.		Distance.	Remarks.
					A _E	A _N		

Alaska. *Sitka. Magnetic Observatory. U. S. Coast and Geodetic Survey. J. W. Green.*

Lat., 57° 03' 00" N.; long., 135° 30' 06" W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & V & T_0 \\ N & 10 & 15 \end{cases}$

1918.			H. m. s.	Sec.	μ	μ	Km.	
June 17	P	16 28 25	2	30				Probably local.
	M _E	16 28 42						
	C _N	16 29 40						
	F _E	16 33						

Arizona. *Tucson. Magnetic Observatory. U. S. Coast and Geodetic Survey. F. P. Ulrich.*

Lat. 32° 14' 48" N.; long., 110° 50' 06" W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & V & T_0 \\ N & 10 & 14 \end{cases}$

(Report for June, 1918, not received.)

California. *Berkeley. University of California.*

Lat., 37° 52' 16" N.; long., 122° 15' 37" W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 29' 24" N.; long., 121° 38' 34" W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy. F. J. Dick.*

Lat., 32° 43' 03" N.; long., 117° 15' 10" W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

1918.			H. m. s.	Sec.	μ	μ	Km.	
June 6					300	300		Tremors during 24 hours preceding 15 hours on dates given.
14					250	300		
17					100	100		
19					200	200		
20					200	200		
22					200	300		
25					50	50		

California. *Santa Clara. University of Santa Clara. J. S. Ricard, S. J.*

Lat., 37° 26' 36" N.; long., 121° 57' 63" W. Elevation, 27.43 meters.

(See record of the Seismographic Station, University of Santa Clara.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude.		Distance.	Remarks.
					A _E	A _N		

Colorado. *Denver. Sacred Heart College. Earthquake Station. A. W. Forstall, S. J.*

Lat., 39° 40' 36" N.; long., 104° 56' 54" W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

1918.			H. m. s.	Sec.	μ	μ	Km.	
June 5	P	21 34						Apparent activity at intervals during day.
7	S	21 7						
	L _E	21 36		4	*5,000			
	L _N	21 36		6		*5,000		
	M _E	21 36		4-6	*10,000			
	M _N	21 37		4-6		*9,000		
	C	21 42						Visible waves of long period, more noticeable on N-S.
16-17	F	21 44						

* Trace amplitude.

District of Columbia. *Washington, U. S. Weather Bureau.*

Lat., 38° 54' 12" N.; long., 77° 03' 03" W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants: $\begin{cases} V & T_0 \\ 110 & 6.4 \end{cases}$

1918.			H. m. s.	Sec.	μ	μ	Km.	
June 3	P	0 14 04						
	S	0 22 48						
	L	0 30 20						
	L	0 35		20				
	F	0 50						
4	eL _N	5 12 40		20				
	F _N	5 25						
4	L	18 04 30		20				
	F	18 45						
7	eP	21 33 28						
	S	21 38 33						
	L?	21 41 50						
	L?	21 47 57		12				
	F	22 45						
11	P	12 41 44						
	S	12 45 41						
	L	12 48 30		18				
	F	13 15						
12	P?	4 37 09						
	S?	4 42 20						
	L	4 46 22						
	F	4 55						
13	P	9 04 19						
	S	9 08 46						
	L	9 10 47						
	F	9 30						
16	P	12 33 27						
	S	12 37 57						
	L?	12 40 30						
	F	12 55						
17	e	16 45 37						Phases indistinguishable.
	F	16 55						
22	S?	22 11 53						
	L?	22 17 27						
	L	22 22 50		20				
	F	22 45						

TABLE 2.—Instrumental reports, June, 1918—Continued.

Date.	Charac- ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					A _B	A _N		

District of Columbia. Washington. Georgetown University.
F. A. Tondorf, S. J.

Lat., 38° 54' 25" N.; long., 77° 01' 21" W. Elevation, 42.1 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical

Instrumental constants...

	V	T ₀	ε
E	165	5.4	0
N	143	5.2	0
Z	89	5.0	0

1918.			H. m. s.	Sec.	μ	μ	km.	
June 3	e		0 14 05					Microseisms. e pos- sibly 50 seconds sooner. No dis- tinct M.
	S		0 22 51					
	eL _N		0 30 18	16				
	eL _N		0 30 18	22				
	F		1 00 ..					
4	e _N		17 40 07					Microseisms.
	e _N		17 40 24					
	L _N		18 06 14	24.5				
	L _N		18 06 14	22				
	F		18 30 ..					
7	eP _N		21 34 07					S very doubtful.
	eP _N		21 34 11					
	S _N ?		21 38 31					
	S _N ?		21 38 50					
	eL _N		21 44 00	4				
	eL _N		21 44 06	5.5				
	M _{N1}		21 45 15	*2,500				
	M _{N2}		21 47 22	*1,500				
	M _{N2}		21 48 18			*900		
	F		22 50 ..					
11	eP _N		12 41 42					
	eP _N		12 41 44					
	S		12 45 58					
	eL		12 48 06	13				
	F		13 16 ..					
12	e _N		4 35 24					Microseisms.
	eL _N		4 44 30					
	L _N		4 47 04	10				
	L _N		4 48 02	10				
	F		4 59 ..					
13	iP		9 04 20					
	S		9 09 57					
	eL		9 13 18					
	F		9 26 ..					
16			12 ? ?					Quake lost in changing sheets. Bosch photo- graphic shows: P-S 4m. 32s., S-eL 1m. 30s.
17	e		16 43 15?					Microseisms. Time of phases uncer- tain because of loss of clock cor- rection.
	S _N ?		16 45 50?					
	S _N ?		16 45 54?					
	F		16 57 ..					
22	e		22 12 00					Heavy micro- seisms. e possi- bly 24 seconds sooner. S very doubtful.
	S _N ?		22 16 23					
	eL _N ?		22 18 12					
	L _N		22 21 23	23				
	L _N		22 22 07	16				
	F		22 40 ..					

*Trace amplitude.

Date.	Charac- ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					A _B	A _N		

Hawaii. Honolulu. Magnetic Observatory. U. S. Coast and Geodetic Survey. Frank Neumann.

Lat., 21° 19' 12" N.; long., 158° 03' 48" W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant... 29.4

1918.			H. m. s.	Sec.	μ	μ	Km.	
June 4	P		4 14 12					
	L		4 29 48					
	M		4 34 12	30	*1,900			
	C		4 36 06					
	F		4 57 ..					
4	P		17 26 36					
	L		17 29 24					
	M		17 32 36	29	*1,500			
	C		17 35 42	32				
	F		17 59 ..					
7	e		21 50 48					
	M		21 52 06	29	*100			
	F		21 56 ..					
14	e		21 45 48					Local quake. Mo- tion irregular.
	M		21 47 00		*600			
	C		21 49 36					
	F		21 53 ..					
16	P		5 28 12					
	L		5 35 12	32				
	M		5 36 54	26	*400			
	F		5 48 ..					
21	P		4 28 54					
	eS?		4 34 12					
	L		4 36 54	29				
	M		4 37 30		*100			
	F		4 40 ..					
24	P		14 56 18					
	S		15 04 00	27				
	L		15 11 30	32				
	M		15 14 00	30	*500			
	C		15 15 42					
	F		15 37 ..					
26	P		21 46 06	31				
	L		21 52 12	32				
	M		21 53 42	29	*400			
	C		21 55 00					
	F		22 01 ..					
27	P		21 36 18					
	L		21 42 36	27				
	M		21 46 00		*200			
	F		22 03 ..					

*Trace amplitude.

Kansas. Lawrence. University of Kansas. Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57' 30" N.; long., 95° 14' 58" W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants...

	V	T ₀	ε
E	177	3.4	4:1
N	205	3.4	4:1

(Report for June, 1918, not received.)

TABLE 2.—Instrumental reports, June, 1918—Continued.

Date.	Charac-ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					Λ_E	Λ_N		

Maryland. *Cheltenham. Magnetic Observatory. U. S. Coast and Geodetic Survey. George Hartnell.*

Lat., 38° 44' 00" N.; long., 76° 50' 30" W. Elevation, 71.6 meters.
Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants. $\frac{V}{N} \frac{T_0}{10} \frac{\epsilon}{15}$

1918.			H. m. s.	Sec.	μ	μ	km.	
June 7	eP _E ?		21 34 06	5				P phases doubtful.
	eP _N ?		21 34 18	10				
	P _E ?		21 44 21	4				
	P _N ?		21 44 31	4				
	eL _N ?		21 46 11	12				
	eL _E ?		21 47 25	10				
	M _E ?		21 48 10	12	60			
	M _N ?		21 48 25	12		50		
	C _N ?		21 51	10				
	C _E ?		21 53	10				
11	F _E ?		22 06	9				
	P _N ?		12 41 41	3				
	P _E ?		12 41 43	3				
	S _E ?		12 45 53	3				
	S _N ?		12 45 54	3				
	eL _N ?		12 48 37					
	eL _E ?		12 49 00					
	M _E ?		12 53 45	10	10			
	M _N ?		12 55 09	9		10		
	F _E ?		12 57					
12	F _N ?		13 04					
	e _E ?		4 44 09					
	eL _N ?		4 47 03	12		10		
	eL _E ?		4 48 09	12	10			
13	F _E ?		4 54					
	P _E ?		9 04 20	3				
	M _E ?		9 11 50	3	10			
	M _N ?		9 12 00	3		20		
17	F _E ?		9 31					
	e _E ?		16 46 02					
	M _E ?		16 46 46	3		10		
	M _N ?		16 46 47	3	10			
22	F _E ?		16 50	3				
	eP _N ?		22 12 09	4				
	eS _N ?		22 17 09	4				
	eL _N ?		22 23 12					
	M _N ?		22 25 20	18		10		Phases doubtful, barely perceptible on E.
	F _N ?		22 27					

Massachusetts. *Cambridge. Harvard University Seismographic Station, J. B. Woodworth.*

Lat., 42° 22' 36" N.; long., 71° 06' 59" W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants. $\frac{V}{N} \frac{T_0}{50} \frac{\epsilon}{25} \frac{\epsilon}{4.1}$

1918.			H. m. s.	Sec.	μ	μ	km.	
June 3	O _E ?		0 03 07				7120	E damped by magnet. N undamped: T ₀ =25 sec.
	iP _E ?		0 13 41	4				
	P _E ?		0 13 45					
	S _E ?		0 22 16	6				
	S _N ?		0 22 19					
	eL _E ?		0 28 59	9				
	eL _N ?		0 29 44	23				
	M _E ?		0 31 04	17				
	F _E ?		1 13					
	F _N ?		1 13					
4	O _E ?		4 postea				3600-6000	L _N ? deformed by local vibrations. M _N ?
	C _N ?		5 00 10					
	L _N ?		5 09 39	26?				
	L _E ?		5 11 08	24				
	L _N ?		5 15 38	20				
4	F _E ?		5 28					Difficult to decipher.
	O _E ?		17 05 ca				13000+?	
	eP _E ?		17 20 38					
	S _E ?		17 27 51	6				
	eL _N ?		18 09 30	20				
7	L _N ?		18 15 08	16				Epicenter computed from S _N -P _E . eL _N -S _N gives 7035.
	F _E ?		18 50					
	O _E ?		21 16 12				7040	
	P _E ?		21 26 42					
	S _E ?		21 35 13	6				
	S _N ?		21 35 39	6				
	i _E ?		21 40 06	6				
	C _E ?		21 43 06					
	P _N ?		21 47 03					
	eL _N ?		21 47 03	28				
	L _E ?		21 48 41					A new P?
	M _E ?		21 51 03	13				
	M _N ?		21 51 31	12				
	M _E ?		21 54 19	14				
	F _E ?		22 39					
								N ran down at 22h. 05m.

Date.	Charac-ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					Λ_E	Λ_N		

Massachusetts. *Cambridge. Howard University Seismographic Station—Continued.*

1918.			H. m. s.	Sec.	μ	μ	km.	
11	O _E ?		12 postea					
	e _E ?		12 39 37	4				
	eP _N ?		12 40 08					
	eL _N ?		12 44 26	12				
	e _E ?		12 44 59	6				
	L _E ?		12 50 04	10				
	F _E ?		13 20 24					
	O _E ?		4 21 ca				5610?	
	e _N ?		4 30 34					
	e _E ?		4 32 34	6				
12	e _N ?		4 36 28	4				
	e _N ?		4 44 39	7				
	L _N ?		4 46 05	12				
	L _E ?		4 46 48	14				
	F _N ?		4 56 43					
13	O _E ?		8 58 26				3410?	Time uncertain on North component, on account of broken driving spring.
	O _E ?		8 58 55					
	iP _N ?		9 04 59?	2				
	iP _E ?		9 05 08	2				
	S _N ?		9 10 08?	6				
	S _N ?		9 10 17?	5				
	eL _N ?		9 13 37?	8				
	F _E ?		9 23					
	O _E ?		12 27 44				3330	
	O _E ?		12 27 45?				3170?	
16	iP _N ?		12 33 57?	2-4				Press reports prolonged shock at St. Vincent, W. I. eL uncertain, also L _E and of very short period. Time on N component uncertain. Compare with record of March 25, 1915, $\Delta=3440?$ O, 9h. 03m. 43s.?
	iP _E ?		12 34 11	2-4				
	S _N ?		12 38 58?	6				
	S _E ?		12 39 17	6				
	i _N ?		12 40 08?					
	i _E ?		12 40 35	8				
	i _N ?		12 41 26?					
	F _E ?		12 55					
	O _E ?		16 postea					
	e _E ?		16 45 38	2				
17	to _E ?		16 45 56	4				Possibly local and nonseismic. L microseismic. N (out of order) gives: e 16 45 16 L 16 45 49 to 16 46 15 L 16 48 10 to 16 48 45 F 16 53 ..
	to _E ?		16 46 02	6				
	to _E ?		16 46 49					
	to _E ?		16 49 25	6				
	to _E ?		16 50 12					
	F _E ?		16 56					
	O _E ?		21 56 51				6000?	
	e _N ?		22 12 33					
	iS _E ?		22 13 58	8				
	i _N ?		22 18 24	10				
22	eL _N ?		22 23 09	20				Δ and O very uncertain. e in microseisms.
	L _E ?		22 28 29					
	F _N ?		23					
	O _E ?		22 48 53				10050?	
	S _E ?		23 12 58	6				
26	L _E ?		23 32 56	20				Δ and O very uncertain.
	L _N ?		23 34 12	20				
	F _E ?		23 41					
	O _E ?		21 postea					
	L _N ?		22 00 54?	20				
27	L _E ?		22 01 46?	20				Masked by microseisms.
	L _E ?		22 06 31	15				
	L _E ?		22 12 16	14				
	L _E ?		22 16					
	F _N ?		22 16					

Missouri. *Saint Louis. St. Louis University. Geophysical Observatory. J. B. Goesse, S. J.*

Lat., 38° 38' 15" N.; long., 90° 13' 58" W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants. $\frac{V}{80} \frac{T_0}{7} \frac{\epsilon}{5.1}$

1918.			H. m. s.	Sec.	μ	μ	km.	
June 7	eP _E ?		21 32 30?				2,980?	Time uncertain because of local disturbances.
	S _E ?		21 37 06?					
	L _E ?		21 38 30?					
	M _N ?		21 42 24?	12			*4,500	
	F _E ?		22 18					

*Trace amplitude.

TABLE 2.—*Instrumental reports, June, 1918*—Continued.

Date.	Char-acter.	Phase.	Time.	Per-iod. T.	Amplitude.		Dis-tance.	Remarks.
					A_E	A_N		
New York. <i>Buffalo. Canisius College.</i> John A. Curtin, S. J.								
Lat., $42^{\circ} 53' 02''$ N.; long., $78^{\circ} 52' 40''$ W. Elevation, 190.5 meters.								
Instrument: Wiechert 80 kg. horizontal.								
					V	T_0	ϵ	
Instrumental constants.					80	7	5.1	

New York. *Ithaca. Cornell University. Heinrich Ries.*
 Lat., $42^{\circ} 26' 58''$ N.; long., $76^{\circ} 29' 09''$ W. Elevation 242.6 meters.
 Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

	V	T_0	ϵ
Instrumental constants.	$\int E$	13 22	4:1
	$\int N$	14 25	4:1

(Report for June, 1918, not received.)

Panama Canal.		Balboa Heights.		Governor, Panama Canal.			
Lat., 8° 57' 39" N.; long., 79° 33' 29" W.		Elevation, 27.6 meters.		Instruments: Two Bosch-Omori, 100 kg.			
Instrumental constants..		V		T ₀			
		35		20			
1918							
June 16	-----	P _E ...	H. m. s. 12 29 34	Sec.	μ	μ	km. 630
		P _N ...	12 29 51				Direction probably NW.
		L _E ...	12 30 58	20			
		M _E ...	12 31 05		*2,000		
		L _N ...	12 31 15	20			
		M _N ...	12 31 19			*1,800	
		F _E ...	12 43 16				
		F _N ...	12 43 26				
20	-----	P _E ...	5 24 00				Faint tremors.
		F _E ...	5 36 00	20			Very faint trace on N-S.
22	-----	P _E ...	22 06 44				300
		P _N ...	22 06 50				Direction uncertain.
		L _N ...	22 07 26	20			
		L _E ...	22 07 52	20			
		M _N ...	22 08 28			*11,400	
		M _E ...	22 08 44		*8,000		
		F _N ...	22 24 14				
		F _E ...	22 26 28				
28	-----	P _E ...	8 01 41				385
		P _N ...	8 01 42				Direction uncertain.
		L _N ...	8 02 30	20			
		L _E ...	8 02 33	20			
		M _N ...	8 02 34			*500	
		M _E ...	8 02 36		*500		
		F _N ...	8 10 14				
		F _E ...	8 10 30				

* Trace amplitude.

Porto Rico. *Viques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. L. Adams.

Lat., 18° 09' N.; long., 65° 27' W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

	V	T_0
Instrumental constants...	$\int E$	$\int N$
	10	18
	10	20

1918			<i>H. m. s.</i>	<i>Sec.</i>	μ	μ	<i>km.</i>	
June 7	-----	e _g	21 50 35					Only a few L waves.
		M _g	21 51 20	18	10			
		F _g	21 52 ..					
11	-----	e.....	12 ? ?	5?				Began while sheet was being changed. New sheet started at 12h. 39 m. 03s.
		M _x	12 39 17			90		
		M _g	12 39 41		170			
		F.....	12 50 ..					
22	-----	e _g	22 10 17	6				Only a few waves.
		e _g	22 10 28	6				
		F.....	22 27 ..					

Date.	Char-acter.	Phase.	Time.	Pe-riod. T.	Amplitude.		Dis-tance.	Remarks.
					A _E	A _N		
Vermont. Northfield. U. S. Weather Bureau. Wm. A. Shaw.								
Lat., 44° 10' N.; long., 72° 41' W. Elevation, 256 meters.								
Instruments: Two Bosch-Omorl, mechanical registration.								
					$\begin{matrix} V & T_0 \\ \text{Instrumental constants.} \left\{ \begin{matrix} E & 10 & 15 \\ N & 10 & 16 \end{matrix} \right. \end{matrix}$			

1918			<i>H. m. s.</i>	<i>Sec.</i>	μ	μ	<i>km.</i>
June 7	.....	e.....	21 45 25	.....	.....	.....	.....
		L.....	21 50 30	.....	.....	.....	.....
		F.....	22 15 ..	.....	.....	.....	.....
11	.....	P?.....	12 41 58	.....	.....	.....	.....
		S?.....	12 46 30	.....	.....	.....	.....
		L.....	12 49 20	.....	.....	.....	.....
		F.....	13 10 ..	.....	.....	.....	.....
16	.....	P?.....	12 33 40	.....	.....	.....	.....
		S?.....	12 38 55	.....	.....	.....	.....
		L.....	12 42 ..	.....	.....	.....	.....
		F.....	12 55 ..	.....	.....	.....	.....

Canada. Ottawa. Dominion Astronomical Observatory. Earthquake Station. Otto Klotz.

Lat., $45^{\circ} 23' 38''$ N.; long., $75^{\circ} 42' 57''$ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

$V \quad T_0$
Instrumental constants. . 120 26

1918.			<i>H. m. s.</i>	<i>Sec.</i>	μ	μ	<i>km.</i>
June 3	e.....	0 23 06†					
	eL.....	0 30 ..					
	F.....	1 30 ..					
4	e.....	4 23 36†					
	e.....	4 33 42†					
	e.....	4 43 48†					
	e.....	4 59 ..					
	eL.....	5 02 ..					
	F.....	5 20 ..					
4	e.....	17 29 44	6				12,000
	e.....	17 40 30†	6				
	e.....	18 05 ..	8				
	eL.....	18 08 ..	18				
	L.....	18 15 ..	17				
	L.....	18 37 ..	15				
	F.....	19 ..	15				
7	o.....	21 27 10					3,780
	eP.....	21 34 12					
	Prepl ..	21 35 30					
	S.....	21 39 46					
	Srepl ..	21 41 42					
	eL.....	21 43 56					
	L.....	21 48 ..	12				
	L.....	21 55 ..	8				
	L.....	22 04 ..	7				
	L.....	22 23 ..	7				
	F.....	22 45 ..	7				
11	e.....	12 41 54†					
	eL.....	12 49 24†					
	F.....	13 ..					
12	e.....	4 37 30†					
	eL.....	4 45 48†					
	F.....	5 ..					
13	o.....	8 58 34					3,460
	P.....	9 05 11					
	S.....	9 10 25					
	L?.....	9 13 30†	7				
	L.....	9 15 ..	7				
	F.....	9 40 ..					
16	eL.....	6 10 to 6 35 ..	25 to 18				
16	o.....	12 27 48					3,410
	iP.....	12 34 21					
	i.....	12 35 48					
	eS _N	12 39 30					
	Srepl ..	12 40 36					
	eL.....	12 42 30†					
	F.....	13 ..					
17	i.....	16 43 20	2				
	e.....	16 43 32	5				
	e.....	16 44 52	6				
	e.....	16 45 54†	6				
	F.....	17 ..					
22	i.....	22 15 12†					
	i.....	22 18 36†					
	eL.....	22 26 ..					
24	ii?.....	15 41 54†					
	eL.....	15 46 ..	21				
	F.....	16 ..					
26	eL.....	22 29 ..	28				
	L.....	22 34 ..	18				
	L.....	22 38 ..	17				
	F.....	22 50 ..					

From Deformation Instrument. Seismograph clock stopped. i may not be seismic.

† Original time given tenths of a minute.

TABLE 2.—Instrumental reports, June, 1918—Continued.

Date.	Charac-ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 40' 01" N.; long., 79° 23' 54" W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North; in the meridian.

Instrumental constant... 18. T_0 Pillar deviation, 1 mm., swing of boom = 0.45".

1918.			H. m. s.	Sec.	μ	μ	km.	
June 2	L.		13 41 18†		*50			
	F.		13 44					
3	S?		0 23 42					Microseisms.
	L.		0 31 48					
	L.		0 39 54					
	M.		0 44 12		*1,300			
	F.		1 57 42†					
4	L.		4 59 42					P. S. & F. masked by microseisms.
	L.		5 11 24					
	L.		5 15 30					
	M.		5 18 54		*800			
	F.		5 ? ?					
4	L.		18 02 18					Microseisms going on before L.
	L.		18 08 00					
	M.		18 12 42		*1,600			
	F.		? ? ?					
	L?		19 36 36					
5-6								Heavy microseisms during night and morning.
7	iP.		21 34 54				3,610	Microseisms before and after quake. Boom suddenly moved to west at beginning of L.
	S.		21 40 18					
	iL.		21 48 24					
	M.		21 53 24		*1,300			
	F.		? ? ?					
11	L.		12 48 18					
	L.		12 49 30					
	M.		12 54 48		*800			
	F.		13 28 30					
12	L.		4 46 18					
	M.		4 46 48		*300			
	F.		5 06 48					
13	L.		9 10 48		*50			
	F.		9 38 12					
16	L.		6 19 00					Thickening.
	L.		6 25 36		*200			
	F.		6 47 30					
16	S.		12 37 18					
	L. or S.		12 39 24					
	L.		12 42 18					
	M.		12 46 42		*200			
	F.		13 05 06					
17			16 43 ?					Light off. Small quake missed.
21	L?		4 45 12					Microseisms going on.
	L.		4 58 12		*100			
22	L.		22 21 00					
	L.		22 24 42					
	M.		22 25 54		*600			
	F.		22 43 48					
24	L?		15 50 12					
	L.		15 58 06					
	M.		16 02 30		*100			
	F.		16 34 48					
26	L.		22 32 06					Very gradual thickening.
	M.		22 39 18		*400			
	F.		23 15 06†					
27	L.		22 01 18					Microseisms going on before L.
	L.		22 05 42					
	M.		22 07 24		*200			
	F.		22 37 42					

* Trace amplitude.

† All readings originally given in tenths of a minute.

Date.	Charac-ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Canada. Victoria, B. C. Dominion Meteorological Service.

Lat., 48° 24' N.; long., 123° 19' W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.

Instrumental constant... 18. T_0 Pillar deviation, 1 mm., swing of boom = 0.54".

1918.			H. m. s.	Sec.	μ	μ	km.	
June 2	P or L.		13 22 25					
	M.		13 22 47		*100			
	F.		13 27 22					
3	P.		0 31 34					
	L.		0 49 16					
	M.		0 57 38		*500			
	F.		1 31 34					
4	P.		4 29 24					
	L.		4 46 15†					
	or		4 51 52					
	M.		4 59 08		*400			
	F.		5 15 01					
4	P.		17 34 35					
	L.		17 49 35					
	M.		18 00 10		*400			
	F.		18 50 19					
5	M.		23 18 33		*100			
7	P.		21 33 58				4,170	
	S.		21 39 55					
	L.		21 45 23					
	M.		21 47 51		*2,000			
	F.		22 44 23					
			VERTICAL		Az			
	P.		21 33 48	5				
	S.		? ? ?					
	L.		21 47 48	9				
	M.		21 49 20	12	4			
	F.		? ? ?					
11	M.		13 13 57		*400			
	F.		13 31 39					
12	L.		4 27 45					
	M.		4 28 44		*400			
	F.		4 41 51					
13	M.		9 22 30		*100			
16	P.		5 46 33†				4,120	
	S.		5 52 27					
	L.		6 00 20					
	M.		6 05 45		*200			
	F.		6 14 06†					
16	L.		12 56 43		*50			
	F.		13 01 37					
21	P.		4 37 03				1,440	
	L.		4 39 32					
	M.		4 42 00		*200			
	F.		4 49 27					
22	L.		22 31 53					
	L.		22 36 48					
	M.		22 44 10		*100			
	F.		22 54 57					
24	P.		15 29 30				2,040	
	S.		15 32 57					
	L.		15 38 51					
	M.		15 44 15		*200			
	F.		15 59 00					
26	L.		22 10 33					
	M.		22 20 57		*400			
	F.		22 30 57					
27	P.		21 40 28					
	M.		21 52 22		*200			
	F.		22 13 11					

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.¹

St. Vincent, B. W. I., June 16, 1918.

A severe and protracted earthquake shock was felt here Saturday morning (June 15). (Assoc. Pr.)

Managua, Nicaragua, June 16, 1918.

Three strong shocks of earthquake were experienced early this morning. No serious damage has been reported. The wires are down to some points in the republic. (Assoc. Pr.)

London, June 16, 1918.

Violent earth shocks were felt in two widely separated parts of Italy, Saturday, June 15, in the town of Salerno, Province of Campania, and in Sicily.

Considerable material damage was caused in both, but no deaths have been reported so far. (Int. News Serv.)

¹ Reported by the organization indicated and collected by the seismological station, at Georgetown University, Washington, D. C.

LATE REPORTS.

Date.	Charac- ter.	Phase.	Time.	Period T.	Amplitude.		Dis- tance.	Remarks.
					A _E	A _N		

Massachusetts. *Cambridge. Harvard University Seismographic Station, J. B. Woodworth.*

Lat., 42° 22' 36" N.; long., 71° 06' 59" W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants. $\begin{matrix} V & T_0 & \epsilon \\ \text{E} & 80 & 23 & 0 \\ \text{N} & 50 & 25 & 4:1 \end{matrix}$

1918.			H. m. s.	Sec.	μ	μ	km.	
May 25	O.....		19 29 54				8050	Omitted in May re- port.
	eP.....		19 40 58	4				
	P.....		19 40 59					
	S.....		19 50 20	10				
	S.....		19 50 33					
	eL.....		20 03 56	30				
	L.....		20 04 13	26				
	F.....		21 27 ..					

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Abbot, C[harles] G[reeley].

On periodicity in solar variation. Washington. 1918. p. 1, 8 p. incl. charts. tables. 24½ cm. At head of title: Smithsonian miscellaneous collection, vol. 69, no. 6. (Publication 2499.)

Anfossi, G[iovanni].

Premières recherches sur l'évaporation d'un lac de l'Appennin génois. Grenoble. 1917. 15 p. 25½ cm. (Extrait du Recueil des travaux de l'Institut de géographie alpine (Université de Grenoble). Tome 5, fasc. 1, 1917.)

Barber, Fred[erick] D[elos].

Indoor humidity. maps. chart. diagr. 23 cm. (Excerpted from Transactions of the Illinois academy of science, v. 10, 1917, p. 294-300.)

Batavia. Magnetisch en meteorologisch observatorium.

Regenwaarnemingen in Nederlandsch-Indië. Acht en dertigste jaargang. 1916. Deel 1-2. Batavia. 1917. 2 v. tables. 26½ cm.

Blackwelder, Eliot.

The climatic history of Alaska from a new viewpoint. (Excerpted from Transactions of the Illinois academy of science, v. 10, 1917, p. 275-280.) 23 cm.

Galli, Ignazio.

Osservazioni inedite e rare di lampi e fulminazioni. Memoria settima. Roma. 1918. 61 p. illus. 28½ cm. (Estratto dalle Memorie della Pontificia accademia Romana dei Nuovi Lincei, serie 2, vol. 3.)

Havana. Observatorio meteorológico, magnético y sísmico del Colegio de Belen de la Compañía de Jesús.

Año de 1917. Habana. 1918. 2 p. l., 14, 8 p. charts. tables. 36 cm.

Salmon, S. C.

Relation of the density of cell sap to winter hardiness in small grains, by S. C. Salmon and F. L. Fleming. Washington. 1918. plate. tables. 26 cm. (Reprinted from Journal of agricultural research, vol. 13, no. 10. p. 497-506.)

U. S. Mississippi river commission.

Stages of the Mississippi river and of its principal tributaries, for 1917 . . . St. Louis. 1918. lxiii, 79 p. incl. tables. 23 cm.

Wallén, Axel.

Vattenståndsförutsägelserna. Granskning af 1917 års resultat och prognoser för år 1918. [Stockholm]. 1918. cover-title. 19 p. map. charts (part. fold.) tables. 20½ cm. At head of title: Från hydrografiska byrån. (Särtryck ur Teknisk tidskrift, 1918. Vågs och vattnebyggnadskonst. Häft. 3.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

Geographical journal. London. v. 52. July, 1918.

Close, Charles. The fluctuations of mean sea-level with special reference to those caused by variations in barometric pressure. p. 51-58.

Geographical review. New York. v. 6. July, 1918.

Recent developments in the theory of glacial variations. p. 75-76.

Medical times. New York. v. 46. July, 1918.

Radway, Jacques W. The electrification of atmospheric dust. p. 177-178.

Pan-American union. Bulletin. Washington. v. 46. June, 1918.

Reid, William A. Studying South American skies. p. 748-759. [Includes description of meteorological as well as astronomical observatories in South America.]

Physical review. Lancaster. v. 11. June, 1918.

Sanford, Fernando. On the formation of negatively electrified rain drops. p. 445-448.

Scientific American. New York. v. 119. July 13, 1918.

The fog problem in aviation. p. 26.

Scientific American supplement. New York. v. 87. 1918.

Blair, William E. Meteorology and aeronautics. The relation of topographic and climatic factors, p. 12-14. (July 6.) [Repr. from Report 13, U. S. Nat. adv. committee for aeronautics.]

Beebe, William. A Kashmir barrage of hail. p. 55. (July 27.) [Repr. Bull. N. Y. Zool. Soc.]

Symons's meteorological magazine. London. v. 53. February, 1918.

Mill, H[ugh] R[obert]. Gunfire in France, rainfall in England. p. 2-5.

Annales de physique. Paris. Tome 9. Mars-avril, 1918.

Boutaric, A. Contribution à l'étude du pouvoir absorbant de l'atmosphère terrestre. p. 113-203.

Archives des sciences physiques et naturelles. Genève. 123 année. 1918.

Maurer, Jules. Une périodicité remarquable des hautes pressions atmosphériques dans les Alpes en hiver. p. 349-355. (Mai.)

Mercanton, P[aul] L[ouis]. Les tirs grêlifuges du vignoble de Lavaux (canton de Vaud) ont-ils été efficaces? p. 438-443. (Juin.)

Cuba. Observatorio nacional. Boletín oficial. Habana. Septiembre, 1917.

Carbonell, Luis Garcia y. Huracan del 25 septiembre de 1917. p. 11-32.

SECTION VII.—THE WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF JUNE, 1918.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Climatological Division, Weather Bureau, Aug. 1, 1918.]

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds for June, 1918, are graphically shown on Chart VII, while the means at the several stations, with the departures from the normal, are shown in Tables I and III.

At the beginning of June the pressure was below the normal over the northern half of the country from the Rocky Mountains eastward. Elsewhere it was generally near the normal, except that in the north Pacific Coast States it was materially above. Relatively high pressure soon overspread most northern and eastern districts, and continued much of the time throughout the first decade, while in the South the pressure was generally near the normal. Lower readings predominated during the first few days of the second decade, after which pressure above the normal prevailed in most northern sections east of the Rocky Mountains until near the end of the decade, when the readings became lower over most districts. The third decade had pressure generally below the normal in all districts, except that during the first few days a moderate high area moved slowly across the northern States, and during the latter half of the period relatively high pressure obtained in the north Pacific Coast States. The month closed with pressure near the normal in all sections except the central portions of the Rocky Mountain and Plateau regions and thence northwesterly to the Pacific, where it was generally above the seasonal average.

For the month as a whole the barometric pressure averaged below the normal throughout the eastern half of the country, and generally over the Pacific Coast States; elsewhere it was, as a rule, above the seasonal average. The departures were generally small, except in the central Rocky Mountain district, where they were +.10 or more.

The pressure distribution was fairly uniform over the country, and the gradients were not sufficiently marked to produce a strong preponderance of wind from any one direction. In the middle and southern Plains and lower Mississippi Valley, however, the winds were very generally from some southerly point, while elsewhere they were unusually variable.

TEMPERATURE.

The month opened rather warm in most eastern districts, and cooler than the average in the southern Plateau States, but elsewhere nearly normal temperatures prevailed. Seasonal temperatures followed in nearly all districts until near the middle of the first decade, when there was a sharp drop over the central and northern districts east of the Rocky Mountains; but at the same time warmer weather prevailed in the more western States, particularly in the far Northwest. During the next several days there was a general warming up in nearly all districts.

About the middle of the month cooler weather overspread most sections east of the Mississippi River, and unusually high temperature prevailed in the West.

After a few days the high temperature advanced to the central valleys, but cooler weather soon followed in the Ohio Valley and Lake regions. Toward the latter part of the second decade, while high temperature continued in the central and southern Plains States and west of the Rocky Mountains, unseasonably low temperature overspread the Lakes region and the North Atlantic States, but was soon followed by warmer weather. During the early days of the third decade there was a sharp drop in temperature from the middle Plains States eastward, with frost in the more northern districts, while high temperature continued in the southern Plains region and west of the Rocky Mountains. About the middle of the decade considerably warmer weather overspread the central valleys and lower Lakes region, and it became somewhat cooler in the upper Mississippi Valley. The last few days of the month brought moderate temperatures to most sections.

For June as a whole the temperature was below the normal from the upper Mississippi Valley eastward and southeastward to the Carolinas. It was about normal along the immediate north Pacific coast, over small portions of extreme western Texas and southeastern New Mexico, and over the extreme northwestern and southeastern portions of Florida. Elsewhere the temperature was above the seasonal average, the excess ranging from 3° to 6° per day from the central Gulf coast northwestward to the Canadian border, and over the greater part of the Rocky Mountains and Plateau regions. A deficiency ranging from 3° to 6° per day occurred in the interior of the Atlantic Coast States from central North Carolina to northern New England.

PRECIPITATION.

At the beginning of the month the weather was generally fair, except that local rains prevailed in the lower Ohio and middle and lower Mississippi valleys. During the next few days showers occurred in the South Atlantic and east Gulf States, the upper Mississippi Valley, and upper Lake region and locally in the far Southwest.

About the middle of the first decade general rains fell from the Rocky Mountains eastward, except in the immediate Gulf Coast States, the rainfall being heavy locally in the Ohio and Mississippi valleys. Toward the close of the decade light showers occurred from the upper Mississippi Valley eastward over the Lake region to New England, and some good rains fell in the central and east Gulf States, Arkansas, and east-central Texas. From the Rocky Mountains westward the decade was practically rainless except for a few light showers in widely scattered districts, and drought conditions continued in nearly the whole of that area.

During the first several days of the second decade showers occurred from the region of the Great Lakes and the Ohio Valley eastward and in Texas and the Southeast, being locally heavy in southern Texas. Toward the middle of the decade light local showers occurred over widely scattered areas, and some heavy rains fell in southern Texas. During the latter part of the decade light local rains occurred in the northern Plains States and in limited areas west of the Rocky Mountains. Severe drought continued in most districts west of the Rocky Mountains, and rain was needed for some crops in the districts to the eastward, particularly in the central valleys.

Early in the third decade general rains occurred from Oklahoma to the upper Lake region, and to the eastward, the rainfall being heavy in the Northeastern States. About the middle of the decade moderate to heavy rains occurred over the Ohio, middle Mississippi, and lower Missouri valleys, and from Maryland southward to the Gulf; also over the Northeastern States and the northern Rocky Mountain district. During the remaining portion of the month unsettled showery weather prevailed in most localities from the Rocky Mountains eastward, and good rains fell in a few localities from the Rocky Mountains westward. In much of that section, however, but little rain fell, and moisture was urgently needed.

For June as a whole precipitation was heavy over small areas in the upper and lower portions of the Mississippi Valley, in the Appalachian regions, in eastern North Carolina, and in portions of Georgia and Florida. Elsewhere over the eastern half of the country rainfall was generally moderate to light, although fairly heavy amounts occurred in many small areas. From the Rocky Mountains westward the rainfall was light as usual, except over a few limited areas, and in some sections of California no precipitation occurred.

RELATIVE HUMIDITY.

The average relative humidity for the month was distinctly less than normal over nearly all portions of the country, the principal exception being the southern Plateau region, where there was a moderate excess. The relative dryness of the atmosphere was most pronounced in the northern Rocky Mountains and in the Middle Plains region.

GENERAL SUMMARY.

For June as a whole the weather was generally favorable for farm work. Corn as a rule made good progress, except that it was somewhat damaged during the latter part of the month by hot, dry weather in Oklahoma and Texas, and by low temperature and frosts in the Lake region and in the Northeast. The generally moderate temperatures and well-distributed showers throughout the South were favorable for the development of cotton, except in portions of Texas, where, during the latter part of the month, lack of sufficient moisture caused considerable deterioration. As a whole the weather was favorable for wheat, which made excellent progress in most sections. The weather was too hot and dry for the proper development of oats, rye, and barley over the area from Kansas to North Dakota and in the North Pacific Coast States. Likewise the weather was unfavorable for potatoes and truck crops over much of the Central and Great Plains States and in the Lake region. Meadows and pastures made rather unsatisfactory progress in many sections because of the lack of sufficient moisture, but where precipitation occurred the ranges showed general improvement. The fruit crop as a whole developed favorably.

SEVERE LOCAL STORMS.

The following notes of severe storms have been extracted from official reports:

Georgia.—Severe thunderstorms occurred in many sections of southern Georgia shortly after 3 p. m., June 17, 1918. Damage by wind was reported over a wide territory, many trees being blown down, cornfields leveled, barns, packing houses, and small dwellings wrecked, some stock killed, and a few people more or less injured.

New Jersey.—Hail occurred as follows: June 5, 1918, near Flemington; June 12, from Princeton to near Freehold, and in Gloucester, Camden, Burlington, Atlantic, and Cumberland counties; June 14, in Camden, Warren, and Hunterdon counties. Estimated damage to fruit and vegetables about \$40,000. June 22, a severe storm occurred over Delaware Bay, touching Fortescue, but did not reach many fields. Five cottages were demolished and automobile tops were punctured by the hail.

Average accumulated departures for June, 1918.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	In.	In.	In.	0-10.		P. ct.	
New England.....	60.8	-2.8	-8.8	3.64	+0.50	-3.60	5.3	0.0	76	-3
Middle Atlantic....	68.0	-2.2	-1.4	3.21	-0.50	-0.90	5.2	+0.1	69	-4
South Atlantic.....	76.2	+0.5	+5.0	3.18	-2.50	-7.80	5.3	+0.3	74	-3
Florida Peninsula...	81.0	+0.6	+4.0	2.65	-4.20	-7.30	5.4	+0.3	75	-3
East Gulf.....	80.1	+2.0	+7.3	4.45	-0.10	-3.90	4.9	-0.1	73	-2
West Gulf.....	82.5	+3.5	+3.9	3.34	-0.10	-4.60	3.8	-0.5	64	-10
Ohio Valley and Tennessee.....	72.4	-0.6	-1.4	3.49	-0.70	-2.60	5.1	+0.1	66	-7
Lower Lakes.....	64.3	-2.7	-4.8	2.84	-0.70	-1.10	5.1	+0.2	64	-5
Upper Lakes.....	60.9	-1.6	-6.3	1.70	-1.00	-0.20	4.9	-0.2	68	-5
North Dakota.....	64.1	+0.5	+14.3	1.24	-2.40	-2.70	4.2	-0.9	64	-5
Upper Mississippi Valley.....	71.4	+0.5	+0.7	3.70	-1.00	-1.90	5.2	+0.2	67	-3
Missouri Valley.....	74.9	+4.0	+10.0	2.42	-1.90	-3.00	3.8	-1.2	64	-3
Northern slope.....	66.9	+4.7	+7.4	1.39	-1.10	-1.50	4.1	-0.7	55	-5
Middle slope.....	77.2	+5.3	+6.9	1.40	-0.20	0.00	3.8	-0.2	55	-6
Southern slope.....	80.4	+3.2	+9.1	1.34	-1.40	-2.70	3.3	-0.5	51	-7
Southern Plateau....	78.4	+3.8	+2.5	0.49	0.00	-0.10	2.9	+0.9	39	+9
Middle Plateau.....	72.9	+7.2	+4.5	0.53	0.00	-1.20	3.4	+0.1	38	0
Northern Plateau....	79.2	+6.1	+12.2	0.71	-0.70	-1.90	3.8	-0.7	43	-9
North Pacific.....	60.7	+2.4	+6.6	0.56	-1.40	-3.60	4.5	-1.5	68	-8
Middle Pacific.....	65.1	+2.8	+4.4	0.06	-0.40	-6.50	3.2	+0.1	61	-3
South Pacific.....	71.2	+5.0	+11.6	0.02	0.00	+2.50	3.4	+0.2	64	-2

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING JUNE, 1917.

The data presented are for June, 1917, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month.

Chart IX (XLVI-55) shows for June, 1917, the averages of pressure, air temperature, water surface temperature, and the prevailing direction of the wind at 7 a. m., 75th meridian time (Greenwich mean noon).

It was found impracticable to show any storm tracks on the chart, as the atmospheric depressions during the month were, for the most part, of slight intensity and their movements were too indefinite to plot accurately.

PRESSURE.

The distribution of the mean atmospheric pressure for the month did not differ materially from the normal. The Azores HIGH was not far from its usual position, although somewhat above the normal in intensity and extent. The isobar of 29.8 inches marks the southern boundary of the Icelandic LOW, which was central near latitude 65° and longitude 20°. The pressure over the entire ocean south of the 40th parallel was uniformly high, and over a large part of that region the changes from day to day were comparatively small.

The following table gives for a number of selected 5-degree squares the average pressure for each of the three

decades of the month, as well as the highest and lowest individual readings reported during the month within the respective squares:

Pressure over the North Atlantic Ocean during June, 1917, by 5-degree squares.

Position of 5-degree squares.		Decade means.			Extremes.			
Latitude.	Longitude.	I.	II.	III.	Highest.		Lowest.	
					Pres- sure.	Date.	Pres- sure.	Date.
		Inches.	Inches.	Inches.	Inches.	June.	Inches.	June.
60-65 N	20-25 W	29.79	29.63	29.90	30.10	30	29.30	18
60-65 N	0-5 E	30.07	29.94	29.83	30.34	6	29.50	23
55-60 N	35-40 W	29.77	29.88	29.95	30.05	3	29.48	8
55-60 N	10-15 W	29.90	29.79	29.95	30.33	29	29.50	23
50-55 N	55-60 W	30.01	30.10	29.94	30.50	12	29.68	24
50-55 N	0-5 E	30.14	30.01	29.98	30.28	3	29.69	20
45-50 N	65-70 W	30.01	30.07	29.95	30.40	11	29.70	15
45-50 N	40-45 W	30.10	30.22	30.13	30.41	16	29.78	27
45-50 N	10-15 W	30.09	29.98	30.15	30.43	30	29.68	19
40-45 N	50-55 W	30.24	30.35	30.15	30.46	12	29.86	7
40-45 N	25-30 W	30.27	30.16	30.42	30.50	23	29.98	23
35-40 N	75-80 W	30.06	30.11	30.08	30.30	12	29.86	15
35-40 N	35-40 W	30.38	30.52	30.48	30.52	21, 25	30.20	14
35-40 N	10-15 W	30.21	30.09	30.24	30.37	30	29.90	19
30-35 N	50-55 W	30.37	30.31	30.35	30.59	26	30.19	25
30-35 N	25-30 W	30.37	30.26	30.44	30.51	23	30.08	16
25-30 N	90-95 W	29.98	30.05	30.06	30.17	17	29.92	1
25-30 N	60-65 W	30.25	30.16	30.23	30.31	3, 11, 30	30.08	19, 21
25-30 N	15-20 W	30.23	30.18	30.22	30.41	11	29.96	16
15-20 N	35-40 W	30.07	30.06	30.08	30.29	11	29.98	1, 16
10-15 N	80-85 W	29.92	29.90	29.91	29.98	3, 23	29.83	11

The mean and extreme values presented in the above table are based on the pressures, for each square on the M. S. daily synoptic charts of the North Atlantic, compiled by the Marine Section of the Weather Bureau.

GALES.

Ordinarily June has fewer gales than any other month, and in this month of 1917 the number reported was even less than normal over the greater part of the ocean. They did not occur on more than two days in any one 5-degree square, while the region below the 40th parallel appeared entirely free, except the square between latitude 35°-40°, longitude 65°-70°, where a southeasterly gale of 50 miles an hour was reported on the 17th.

From the 1st to the 3d a low of gradually decreasing intensity covered the greater part of the region between Iceland and the British coast. On the 1st two vessels between the 56th and 58th parallels and the 28th and 36th meridians experienced northwesterly gales of from 40 to 50 miles an hour, while on the 2d and 3d southwesterly gales were reported about 350 miles north of the Azores. Between the 4th and 7th there was no low pressure area of any consequence over the ocean, although a few reports, received from vessels in widely scattered localities, denoted winds of gale force. On the 8th a well-developed low of 29.40 in. was central near latitude 55°, longitude 40°, and westerly gales of from 50 to 55 miles an hour prevailed over the southerly quadrants. This low moved eastward, and on the 9th the center was near latitude 56°, longitude 33°, without change in intensity. Probably also the wind velocities had changed but little, although so few reports were received from the southerly and southeasterly quadrants that it was impossible to determine the conditions accurately. On the 10th and 11th there was evidence of little change in the intensity and position of this disturbance, and no gale reports were received on either of these dates. On the 12th it began to decrease in intensity, and apparently remained over the northeastern division of the ocean until the 24th, although, as stated before, it was impracticable to plot its movements with any degree of accuracy on account of lack of observations from that part of the ocean.

On the 23d an area of low pressure of slight intensity covered a large portion of the Gulf of St. Lawrence, ex-

tending as far south as the 40th parallel. Moderate gales were encountered over a limited area between St. Johns, Newfoundland, and the 52d parallel, and they also occurred over the eastern part of the steamer lanes. The easterly drift of this low was slight, and on the 24th and 25th the center was some distance north of St. Johns; it had gradually decreased in intensity, and on both of these dates the winds were from light to moderate with fog off the coast of Nova Scotia. On the 27th three lows were observed over the northern division of the ocean. The first was central near Father Point, Quebec, the second at latitude 51°, longitude 43°, and the third about 300 miles west of the south coast of Ireland. Wind and weather still remained moderate, no gales were reported, and fog still enveloped a large portion of the western division of the steamer lanes. On the 28th, the first low of the 27th was central over the northern part of Newfoundland, the second had disappeared, and the third was central near Brest, France. Moderate winds were still the rule, although one vessel near latitude 55°, longitude 42°, encountered a westerly gale of 40 miles an hour. On the 30th Quebec was the center of a well-developed low, and the European disturbance had disappeared, the month ending with light to moderate winds over all sections of the ocean, and fog prevailing off the Banks of Newfoundland.

AIR TEMPERATURE.

The average monthly temperature of the air over the ocean did not, as a rule, vary greatly from the normal. The largest departures occurred in the waters adjacent to the coast of New England, where they ranged from -2° to -4°, and in the Gulf of Mexico they were also slightly negative. Along the European coast it was somewhat warmer than usual, and over the middle section of the steamer lanes the departures were variable, ranging from +2° to -2°. In the vicinity of the Azores the air temperatures were practically normal, the same conditions holding true over the greater part of the ocean south of the 40th parallel, the only exception being over a limited territory in the northeast trade wind region, where positive departures of 2° occurred. The seasonal rise in temperature was marked over the northern division of the ocean, the monthly average ranging from 2° to 4° above the mean of the first decade.

The fluctuations in temperature from day to day were comparatively small, and in the square that includes the east coast of Labrador, where they are usually the greatest, the temperature range was only 10°, from 38° on the 9th, to 48° on a number of days during the last decade of the month.

The following table gives the temperature departures for the month at a number of Canadian and United States Weather Bureau Stations on the Atlantic and Gulf coasts.

	°F.		°F.
St. Johns, N. F.	+5.5	Norfolk, Va.	-0.2
Sydney, C. B. I.	+2.7	Hatteras, N. C.	-0.5
Halifax, N. S.	-0.9	Charleston, S. C.	-0.9
Eastport, Me.	-2.8	Key West, Fla.	-0.6
Portland, Me.	-4.4	Tampa, Fla.	+1.6
Boston, Mass.	-0.0	Mobile, Ala.	-0.2
Nantucket, Mass.	-0.7	New Orleans, La.	+0.8
Block Island, R. I.	-0.4	Galveston, Tex.	-0.6
New York, N. Y.	-0.2	Corpus Christi, Tex.	+0.2

WATER SURFACE TEMPERATURES.

Off the Banks of Newfoundland the departure of the average monthly water surface temperature from the normal, was considerably greater than the air tem-

perature departure, while over the remainder of the ocean the air and water temperature departures did not differ materially, and the seasonal rise during the month, as well as the daily fluctuations, were about the same for the two elements.

FOG.

Fog was usually prevalent over the western division of the steamer lanes, the maximum amount occurring in the square between latitude 40°-45°, longitude 60°-65°, where it was reported on 22 days, a percentage of 73, while the normal percentage for the month ranges from 20 to 30.

Off the Banks of Newfoundland where the greatest amount usually occurs, with a percentage of from 60 to 65, it was observed during June, 1917, on only 7 days, or 23 per cent. Over the mid-section of the steamer routes it occurred on from 3 to 8 days. Owing to the present lack of vessel reports it is impossible to state its frequency in European waters.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and

Hail was recorded on the 17th by a vessel near latitude 61°, longitude 22°, this being the only report received during the month.

Winds of 50 mis./hr. (22.4 m./sec.) or over, during June, 1918.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
Buffalo, N. Y.	11	60	nw.	Norfolk, Va.	12	60	w.
Burlington, Vt.	12	50	se.	Oklahoma, Okla.	29	74	nw.
Columbus, Ohio.	30	50	w.	Pensacola, Fla.	17	58	e.
Del Rio, Tex.	13	54	se.	Pierre, S. Dak.	25	54	nw.
Detroit, Mich.	27	50	sw.	Point Reyes Light, Cal.	6	59	nw.
El Paso, Tex.	5	54	ne.	Do.	13	60	nw.
Hatteras, N. C.	26	52	sw.	Do.	14	60	nw.
Houghton, Mich.	1	52	sw.	Providence, R. I.	22	58	se.
Jacksonville, Fla.	30	52	nw.	San Antonio, Tex.	2	54	e.
Louisville, Ky.	28	60	n.	Sault Ste. Marie, Mich.	7	50	nw.
Marquette, Mich.	11	56	sw.	Savannah, Ga.	22	50	nw.
Mobile, Ala.	13	51	e.				
New York, N. Y.	22	50	nw.				
Do.	23	55	nw.				

Condensed climatological summary of temperature and precipitation by sections, June, 1918.

Section.	Section average.		Temperature.						Precipitation.					
			Monthly extremes.						Greatest monthly.					
			Station.	Highest.	Date.	Station.	Lowest.	Date.	Station.	Amount.	Station.	Amount.	Station.	Amount.
Alabama	79.7	+ 1.4	Decatur	107	17	2 stations	50	14†	Camp Hill	8.36	Tuscaloosa	1.52		
Arizona	77.5	+ 4.3	2 stations	119	11	Williams	28	1	Walnut Grove	4.03	2 stations	0.00		
Arkansas	80.5	+ 4.1	Bee Branch	110	20	Okay	19	13	Fulton	12.07	Searcy	0.50		
California	72.6	+ 3.6	Greenland Ranch	124	27	Tamarack	27	1	Barstow	2.97	76 stations	0.00		
Colorado	65.0	+ 4.7	3 stations	105	11†	Steamboat Springs	19	2	Goodpasture	5.90	2 stations	0.00		
Florida	80.4	+ 0.6	Lake City	106	3	Brooksville (2)	58	19	Jasper	10.41	Key West	0.43		
Georgia	79.2	+ 1.4	Bainbridge	105	16	Tate	47	23	Tate	7.12	2 stations	2.01		
Hawaii, May	72.7	- 0.5	Mahukona	95	26	Waimea	48	11	Honolulu	37.76	3 stations	0.00		
Idaho	66.9	+ 7.1	2 stations	110	11†	Stanley	14	2	2 stations	3.16	Geneva	0.04		
Illinois	72.1	+ 0.8	2 stations	105	17	Johet	38	22	Fairfield	7.46	Antioch	0.89		
Indiana	70.8	- 0.8	2 stations	102	16	Laporte	30	23	Royal Center	4.88	Crawfordsville	1.10		
Iowa	70.8	+ 1.7	2 stations	104	16†	West Bend	38	2	Monroe	10.19	Audubon	1.55		
Kansas	78.4	+ 5.5	Chapman	111	29	2 stations	38	30	Coldwater	4.08	Utica	0.08		
Kentucky	73.6	- 0.1	Hopkinsville	104	17	Anchorage	37	23	London	7.64	Brownsville	1.22		
Louisiana	82.7	+ 2.8	Angola	109	15	Kelly (near)	58	14	Calhoun	9.53	Paradis	0.47		
Maryland-Delaware	68.8	+ 1.2	Seaford, Del.	99	2	Oakland, Md.	34	21	Peer Park, Md.	4.37	Emmitsburg, Md.	1.28		
Michigan	62.0	- 2.2	Allegan	98	16	Humboldt	22	23	Iron Mountain	4.77	Port Huron	0.51		
Minnesota	64.4	+ 0.1	Pipestone	99	6	Duluth (near)	24	11	Stillwater	6.24	Pipestone	0.17		
Mississippi	81.2	+ 2.5	Tupelo	107	16	Batesville	52	14	Lake	8.08	Pontotoc	0.85		
Missouri	77.2	+ 3.9	Amoret	110	20	Louisiana	48	8†	Lockwood	8.06	Amoret	0.62		
Montana	65.0	+ 5.3	Jordan	108	14	Bowen	20	29	Dell	3.64	Valentine	0.07		
Nebraska	73.5	+ 4.4	4 stations	108	15	Harrison	32	30	Santee	6.06	Haigler	0.23		
Nevada	71.6	+ 7.1	Logandale	114	11†	Beowawe	21	1	Millett	3.36	Duck Flat	0.00		
New England	60.7	- 3.4	Springfield, Mass.	95	1	Pittsburg, N. H.	26	20	New Haven, Conn.	6.10	Easton, Mass.	1.94		
New Jersey	66.3	- 2.8	Tuckerton	96	2	Boonton	32	21	Flemington	6.21	Bridgeton	1.35		
New Mexico	71.9	+ 2.8	Artesia	116	29	2 stations	25	1	Hobbs	5.67	3 stations	0.00		
New York	61.7	+ 3.2	Port Jervis	97	1	2 stations	24	20	2 stations	6.05	West Point	1.54		
North Carolina	72.7	+ 0.8	Goldsboro	104	2	Jefferson	37	24	Tryon	8.59	Lillington	1.11		
North Dakota	63.3	+ 0.5	4 stations	102	10	Marstonmoor	27	30	Pembina	3.92	Parshall	0.09		
Ohio	68.8	- 0.5	2 stations	98	17	Green Hill	33	24	Mount Healthy	7.75	Dover	0.55		
Oklahoma	81.4	+ 5.0	2 stations	112	25†	2 stations	45	1	Broken Bow	7.30	Hooker	0.64		
Oregon	66.1	+ 6.1	2 stations	107	20†	3 stations	18	1	Hilgard	2.57	15 stations	0.00		
Pennsylvania	66.0	- 1.7	3 stations	98	2	West Bingham	29	20	Ridgway	6.83	Media	0.44		
Porto Rico	78.3	- 0.1	2 stations	99	6†	2 stations	55	15†	Maricao	10.93	Isidora	1.59		
South Carolina	77.0	- 0.5	Blackville	106	5	2 stations	50	20†	Landrum	7.69	Charleston	0.27		
South Dakota	68.3	+ 2.2	Hardingrove	110	10	2 stations	32	2†	Sioux Falls	5.77	Hardingrove	0.30		
Tennessee	75.8	+ 1.6	Savannah	105	17	Erasmus	40	23	Walling	7.72	Savannah	1.75		
Texas	83.3	+ 3.4	Barstow	114	28	Clint	38	1	Clarksville	7.43	Anderson	0.06		
Utah	69.8	+ 7.0	St. George	115	12	Blacks Fork	20	29	Blacks Fork	3.11	2 stations	0.00		
Virginia	69.8	- 1.9	Danville	103	1†	Burkes Garden	38	8	Blacksburg	9.71	Winchester	1.74		
Washington	64.4	+ 3.8	Wheeler	108	21	4 stations	25	1†	Forks	2.47	6 stations	0.00		
West Virginia	68.2	- 1.0	Ryan	99	17	Bluefield	34	24	Marlington	10.11	New Cumberland	0.87		
Wisconsin	63.9	- 0.8	3 stations	97	16	Big St. Germain Dam	24	23	River Falls	5.31	Spooner	0.48		
Wyoming	63.8	+ 5.6	Worland	104	10	Foxpark	19	30	Willow Springs, Ranger Station	5.01	Afton	0.30		

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

(See the Review, January, 1918, p. 48.)

TABLE I.—Climatological data for Weather Bureau Stations, June, 1918.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + min. +2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean maximum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.							Prevailing direction.	Maximum velocity.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Fl.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	In.	In.	Miles.	Miles.	Direction.	Miles per hour.	Direction.	Date.	0-10	In.	In.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
New England.																																		76	3.64	+0.5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														</

TABLE I.—Climatological data for Weather Bureau Stations, June, 1918—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Precipitation.			Wind.																																											
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. +2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity.			Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.																																
																							Miles per hour.	Direction.	Date.																																						
Ohio Valley and Tennessee.																																	66	3.49	-0.7																												
Chattanooga.....	762	189	213	29.16	29.95	-0.05	76.6	+1.2	97	17	86	58	24	67	29	68	64	2.86	-1.4	14	5,088	w.	36	nw.	12	8	12	10	5.6																																		
Knoxville.....	996	102	111	28.91	29.94	-0.06	74.8	+1.4	98	17	84	54	24	66	32	67	64	5.10	+0.9	11	3,928	sw.	48	n.	17	6	13	11	5.9																																		
Memphis.....	399	76	97	29.55	29.96	-0.01	80.4	+2.7	97	16	89	62	23	72	32	72	68	3.96	-0.4	6	4,646	n.	42	n.	28	14	11	5	3.9																																		
Nashville.....	546	168	191	29.38	29.96	-0.03	77.0	+0.7	100	17	87	55	24	67	31	67	62	2.70	-1.7	8	5,583	nw.	43	w.	5	11	14	5	4.5																																		
Lexington.....	989	193	230	28.92	29.96	-0.04	72.2	-1.0	94	16	82	48	23	62	29	64	59	3.61	-0.4	10	8,448	sw.	40	sw.	30	13	11	6	4.4																																		
Louisville.....	525	219	255	29.39	29.97	-0.01	73.6	-1.4	96	16	84	50	23	63	29	64	59	4.24	0.0	8	7,548	n.	60	n.	28	15	11	4	3.2																																		
Evansville.....	431	139	175	29.50	29.95	-0.01	75.9	+0.6	101	16	86	53	23	66	28	66	61	2.05	-2.1	9	7,068	sw.	38	se.	28	7	19	4	5.0																																		
Indianapolis.....	822	194	230	29.08	29.95	-0.02	71.2	-1.2	94	16	82	44	23	61	33	61	54	3.11	-1.2	9	7,522	sw.	43	nw.	30	11	11	8	4.9																																		
Terre Haute.....	575	96	129	29.33	29.94	-0.01	72.4	-1.3	98	16	83	49	8	63	30	64	58	3.58	-2.0	7	6,049	sw.	35	nw.	30	3	20	7	6.0																																		
Cincinnati.....	628	11	51	29.29	29.95	-0.04	70.4	-1.3	93	16	82	46	23	59	31	62	57	4.57	+2.0	9	4,576	n.	26	se.	5	11	11	8	4.8																																		
Columbus.....	824	173	222	29.10	29.96	-0.03	69.7	-1.3	91	29	80	44	23	59	30	61	55	1.25	-2.2	7	7,490	sw.	50	w.	30	7	14	9	5.6																																		
Dayton.....	899	181	216	28.99	29.92	-0.03	70.2	-2.0	92	16	81	44	23	59	32	61	56	2.87	-1.1	7	6,757	sw.	37	w.	30	9	12	9	5.3																																		
Pittsburgh.....	842	353	410	29.07	29.96	-0.03	68.0	-3.1	88	5	78	47	23	59	31	59	53	2.40	-1.5	11	8,557	nw.	40	nw.	12	4	14	12	6.4																																		
Elkins.....	1,940	41	50	27.96	29.97	-0.03	63.9	-2.7	86	1	76	38	24	52	43	58	55	5.32	+0.3	14	3,308	nw.	27	w.	30	5	12	13	6.6																																		
Parkersburg.....	638	77	84	29.32	29.98	-0.02	70.0	-1.5	92	1	80	45	23	60	35	63	59	3.39	-1.3	7	3,751	se.	24	nw.	12	11	13	6	4.9																																		
Lower Lake Region.																																	64	2.84	-0.7																												
Buffalo.....	767	247	280	29.12	29.94	-0.03	61.8	-3.5	85	30	70	41	23	54	25	55	50	2.81	-0.3	13	11,081	sw.	60	nw.	11	7	16	7	5.8																																		
Canton.....	448	10	61	29.44	29.91	-0.05	59.6	-6.2	85	1	70	35	20	49	31	.....	.....	3.57	+0.1	13	7,194	sw.	39	sw.	12	13	8	9	4.8																																
Oswego.....	335	76	91	29.92	29.92	-0.05	58.8	-5.0	86	1	68	40	23	50	33	.....	.....	3.16	-0.3	13	6,742	w.	34	sw.	11	11	11	8	.....																																	
Rochester.....	523	97	113	29.38	29.94	-0.03	62.6	-3.5	88	1	72	40	23	53	33	55	48	2.40	+0.7	12	6,095	sw.	34	w.	12	14	10	6	4.7																																		
Syracuse.....	597	97	113	29.30	29.95	-0.02	62.0	-4.9	88	1	71	40	23	53	28	.....	.....	4.22	+0.3	12	8,143	s.	43	nw.	29	12	10	8	5.0																																
Eric.....	714	130	166	29.18	29.94	-0.04	64.8	-2.2	87	1	72	45	23	57	27	58	53	4.45	+0.7	13	9,806	s.	42	sw.	11	6	13	11	5.8																																		
Cleveland.....	762	190	201	29.14	29.95	-0.03	67.4	-0.5	88	1	75	49	22	60	29	59	54	1.83	-1.8	9	9,276	ne.	43	w.	12	12	12	6	4.9																																		
Sandusky.....	629	62	103	29.27	29.95	-0.03	68.2	-0.6	91	1	77	51	13	60	31	60	55	1.25	-2.6	8	8,598	sw.	40	w.	30	7	13	10	5.5																																		
Toledo.....	628	208	243	29.28	29.96	-0.01	67.6	-1.8	91	16	78	44	23	58	33	59	52	1.53	-1.8	8	9,403	sw.	44	sw.	1	14	10	6	4.3																																		
Fort Wayne.....	856	113	124	29.05	29.97	-0.03	68.3	-0.2	94	16	80	41	23	57	33	60	55	3.09	.....	5	5,968	sw.	38	nw.	6	7	16	7	5.3																																	
Detroit.....	730	218	245	29.18	29.96	-0.01	66.6	-1.2	88	16	77	45	23	56	36	58	52	3.30	-0.6	8	8,285	e.	50	sw.	27	10	17	3	4.6																																		
Upper Lake Region.																																	68	1.70	-1.6																												
Alpena.....	609	13	92	29.28	29.94	-0.02	58.7	-1.6	85	28	68	36	10	49	36	52	47	3.00	-0.6	7	8,712	nw.	40	n.	11	11	12	7	5.0																																		
Escanaba.....	612	54	60	29.28	29.94	-0.00	58.6	-2.0	89	11	68	34	23	50	36	52	47	1.53	-2.1	8	7,372	s.	36	nw.	11	10	14	6	4.4																																		
Grand Haven.....	632	54	60	29.27	29.94	-0.02	62.2	-2.5	80	16	70	43	23	54	30	55	49	1.54	-1.0	3	7,601	w.	36	s.	11	14	12	4	4.0																																		
Grand Rapids.....	707	70	87	29.19	29.95	-0.02	66.2	-1.9	92	16	77	38	23	55	32	58	51	1.17	-1.4	5	4,578	w.	27	nw.	12	12	13	5	4.6																																		
Houghton.....	684	62	99	29.17	29.89	-0.05	57.6	-1.8	85	15	67	38	23	48	37	.....	.....	1.55	-1.9	10	7,705	e.	52	sw.	1	7	12	11	5.6																																
Lansing.....	878	11	62	29.02	29.95	-0.03	64.4	-3.0	90	16	77	35	23	51	38	57	52	2.07	-1.3	10	3,853	sw.	22	w.	1	8	12	10	5.5																																		
Ludington.....	637	60	66	29.26	29.95	-0.03	58.0	-2.7	79	16	66	39	23	50	27	54	51	1.64	.....	9	6,762	s.	31	s.	1	12	11	7	4.8																																	
Marquette.....	734	77	111	29.15	29.95	-0.01	57.1	-1.4	86	11	66	41	23	48	35	52	48	2.51	-1.0	13	7,799	nw.	56	sw.	11	7	13	10	5.6																																		
Port Huron.....	638	70	120	29.25	29.94	-0.03	61.8	-2.0	85	1	72	39	8	52	35	56	51	0.51	-2.7	6	7,540	ne.	37	w.	1	15	12	3	3.5																																		
Saginaw.....	641	48	82	29.20	29.94	-0.03	64.3	-2.3	76	1	66	38	23	53	36	56	49	1.38	-1.3	7	6,578	nw.	33	nw.	12	10	8	12	5.2																																		
Sault Sainte Marie.....	614	11	61	29.24	29.93	-0.03	55.3	-2.3	76	1	66	35	8	45	34	51	46	2.56	-0.2	9	7,188	w.	50	nw.	7	11	11	8	5.1																																		
Chicago.....	823	140	310	29.09	29.96	-0.00	66.9	+0.6	93	11	75	51	23	59	39	59	53	1.69	-2.0	11	7,676	n.	36	w.	6	13	14	3	4.3																																		
Green Bay.....	617	106	144	29.27	29.93	-0.02	63.2	-1.9	88	11	72	42	23	54	35	57	52	2.59	-1.0	8	6,538	s.	30	s.	11	6	10	14	6.5																																		
Milwaukee.....	681	119	133	29.22	29.95	-0.00	62.6	-0.9	91	11	71	48	23																																																		

TABLE I.—Climatological data for Weather Bureau Stations, June, 1918—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Precipitation.			Wind.							Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.			
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean maximum.	Mean minimum.	Date.	Mean maximum.	Mean minimum.	Date.	Mean maximum.	Mean minimum.	Date.	Mean wet thermometer.	Mean temperature of dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity.						Clear days.	Partly cloudy days.	Cloudy days.
																								Miles per hour.	Direction.	Date.						
Northern Slope.																																
Billings.....	3,140	5	44	27.31	29.89	+0.04	70.0	106	14	87	39	1	53	46	54	45	52	1.45	-1.4	6	5,229	sw.	36	sw.	26	18	10	0	2	3.8	.....	.....
Hayden.....	2,505	11	44	27.31	29.89	+0.04	67.2	+4.8	100	14	82	36	1	52	41	51	40	52	0.87	-1.2	9	5,877	nw.	40	w.	12	12	13	5	4.5	.....	.....
Helena.....	4,110	87	114	25.81	29.92	+0.01	66.2	+5.6	94	9	81	36	1	52	41	51	40	52	0.78	-1.2	7	4,404	n.	30	nw.	26	12	13	5	4.3	.....	.....
Kalispell.....	2,962	11	34	26.91	29.92	+0.03	62.2	+3.4	95	9	77	31	3	48	43	50	39	52	0.61	-2.2	10	4,355	n.	28	n.	5	18	12	0	3.2	.....	.....
Miles City.....	2,371	26	48	27.44	29.93	+0.08	72.3	+6.3	105	14	85	46	16	60	36	59	51	55	0.61	-2.2	12	5,594	w.	48	n.	25	8	16	6	4.9	.....	.....
Rapid City.....	3,259	50	58	26.62	29.97	+0.12	68.4	+4.6	99	10	80	41	2	57	32	58	50	54	1.23	-2.4	10	7,486	w.	36	nw.	5	11	12	7	4.7	.....	.....
Cheyenne.....	6,088	84	101	24.10	29.94	+0.10	65.1	+3.6	90	10	78	35	30	52	37	53	45	57	1.24	-0.3	12	6,661	sw.	24	se.	20	11	16	3	.....	.....
Lander.....	5,372	60	68	26.93	29.93	.....	67.2	+5.9	96	14	84	36	1	51	45	58	42	52	1.27	.....	11	3,563	nw.	36	sw.	14	11	12	7	4.4	.....	.....
Sheridan.....	3,790	10	47	26.13	29.96	.....	67.0	.....	98	10	81	35	2	53	40	58	52	62	1.27	.....	13	4,899	s.	22	sw.	13	8	20	2	4.6	.....	.....
Yellowstone Park.....	6,200	11	48	23.97	29.97	+0.11	59.7	+3.7	86	11	73	30	1	46	35	49	42	59	2.97	+1.3	13	4,899	s.	22	sw.	13	8	20	2	4.6	.....	.....
North Platte.....	2,821	11	51	27.08	29.94	+0.08	73.8	+5.4	103	15	87	44	30	60	42	63	57	61	2.18	-1.1	6	4,621	se.	25	se.	28	23	4	3	2.5	.....	.....
Middle Slope.																																
Denver.....	5,292	106	113	24.80	29.94	+0.10	71.2	+4.8	94	14	84	45	1	58	34	56	47	50	0.86	-0.6	7	4,470	s.	23	nw.	5	13	13	4	4.2	.....	.....
Pueblo.....	4,685	80	86	25.33	29.91	+0.08	74.0	+5.0	95	11	89	45	1	59	42	56	45	45	1.02	-0.4	8	4,888	nw.	31	nw.	18	14	12	4	4.2	.....	.....
Concordia.....	1,392	50	58	28.47	29.90	.....	78.9	+6.2	105	11	91	53	30	67	36	65	58	54	1.85	-3.1	6	5,686	s.	35	ne.	29	16	11	3	3.5	.....	.....
Dodge City.....	2,509	11	51	27.37	29.89	+0.02	77.9	+4.8	104	26	91	52	1	65	35	64	57	61	0.26	-3.1	4	7,073	s.	40	nw.	29	20	8	2	3.1	.....	.....
Wichita.....	1,358	139	158	28.50	29.89	+0.02	79.8	+5.5	102	20	90	58	30	69	30	67	61	61	1.29	-3.5	3	8,403	s.	37	se.	23	18	9	3	3.4	.....	.....
Altus.....	1,410	4	.....	.....	.....	.....	83.5	.....	111	26	98	54	1	69	42	.....	.....	.....	1.20	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Muskogee.....	1,632	4	.....	.....	.....	.....	81.5	.....	105	26	93	60	13	70	35	.....	.....	.....	1.59	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oklahoma.....	1,214	10	47	28.66	29.90	+0.01	81.3	+5.6	104	26	93	62	1	70	35	69	64	62	3.09	-0.0	10	7,404	s.	74	nw.	29	14	11	5	4.1	.....	.....
Southern Slope.																																
Atlatene.....	1,738	10	52	28.13	29.88	.....	84.0	+5.8	108	23	96	61	1	71	33	68	61	54	1.56	-1.6	6	6,202	s.	31	ne.	2	15	9	6	4.3	.....	.....
Amarillo.....	3,676	10	49	28.01	29.91	+0.06	77.3	+5.3	103	23	90	54	1	64	41	.....	.....	.....	1.43	-1.6	6	6,727	s.	26	sw.	24	16	11	3	.....	.....	.....
Del Rio.....	3,644	64	71	28.91	29.87	+0.02	83.2	+1.1	100	28	92	68	13	74	29	.....	.....	.....	2.08	-0.4	7	6,458	se.	34	se.	13	20	7	3	2.7	.....	.....
Roswell.....	3,506	75	85	26.34	29.86	+0.06	77.0	+0.7	100	29	91	47	1	62	44	60	48	45	0.29	-1.8	3	5,372	s.	42	s.	13	18	11	1	3.0	.....	.....
Southern Plateau.																																
El Paso.....	3,762	110	133	26.14	29.79	+0.04	80.4	+0.8	105	29	92	51	1	68	36	61	49	39	0.83	+0.3	7	8,319	se.	54	ne.	5	18	12	0	2.9	.....	.....
Santa Fe.....	7,013	57	66	23.35	29.86	+0.05	68.4	+2.2	90	11	80	45	1	56	32	52	42	46	0.68	-0.4	7	5,169	sw.	34	nw.	12	10	20	0	.....	.....	.....
Flagstaff.....	6,908	8	57	23.42	29.83	+0.05	64.7	+5.4	91	12	82	32	2	48	46	.....	.....	.....	0.72	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix.....	1,108	76	81	28.60	29.71	+0.03	88.6	+4.2	114	11	105	58	1	73	45	66	53	36	0.08	0.0	1	3,995	w.	36	se.	14	25	4	1	2.1	.....	.....
Yuma.....	1,141	9	54	23.57	29.71	+0.03	90.4	+5.7	113	11	106	61	4	75	43	69	58	41	0.02	0.0	2	4,184	sw.	38	se.	18	30	0	0	0.7	.....	.....
Independence.....	3,910	11	42	25.93	29.88	+0.10	77.6	+4.2	101	27	92	52	1	63	38	57	40	33	0.13	0.0	5	4,257	nw.	26	se.	15	14	8	8	3.9	.....	.....
Needles.....	488	4	.....	29.20	29.68	.....	92.0	.....	122	11	110	59	2	74	47	.....	.....	.....	0.88	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Middle Plateau.																																
Reno.....	4,532	74	81	25.46	29.86	.....	71.0	+10.0	96	27	88	37	1	54	44	53	40	41	0.14	-0.1	3	4,615	w.	28	w.	23	21	7	2	2.6	.....	.....
Tonopah.....	6,080	12	20	24.09	29.87	.....	72.3	.....	92	12	84	47	1	61	27	39	36	36	0.85	+0.4	6	5,126	se.	36	se.	30	20	9	1	2.5	.....	.....
Winemucca.....	4,344	18	56	25.60	29.83	+0.03	70.6	+7.3	100	11	89	33	1	52	47	52	39	45	1.33	+0.7	9	3,761	ne.	37	sw.	29	13	10	7	4.0	.....	.....
Modena.....	5,479	10	43	24.63	29.85	+0.03	70.4	+7.2	99	12	88	36	2	52	46	50	29	30	0.35	0.0	2	7,533	w.	37	n.	12	12	13	5	4.4	.....	.....
Salt Lake City.....	4,390	103	203	25.61	29.88	+0.03	75.4	+7.1	101	12	88	44	1	63	33	59	48	43	0.20	-0.6	4	4,989	nw.	46	w.	18	15	10	5	4.0	.....	.....
Grand Junction.....	4,602	82	96	25.38	29.88	+0.05	77.0	+4.4	101	11	92	43	1	62	38	56	40	33	0.33	-0.1	2	4,377	se.	44	se.	18	15	10	5	4.0	.....	.....
Northern Plateau.																																
Baker.....	3,471	48	53	26.43	29.96	+0.01	65.6	+7.0	94	13	82	30	1	49	46	52	43	51	0.19	-1.0	3	4,381	se.	33	e.	17	14	11	5	3.7	.....	.....
Boise.....	2,739	78	86	27.11	29.91	.....	73.2	+7.2	100	13	88	37	1	58	39	56	44	44	0.58	-0.3	6	3,478	se.	38	s.	12	13	10	6	.....	.....	.....
Lewiston.....	757	40	48	.....	29.93	.....	72.6	+6.5	103	20	89	40	3	56	45	.....	.....	.....	0.55	-0.5	4	2,655	ne.	22	sw.	13	15	9	6	4.0	.....	.....
Pocatello.....	4,477	60	68	25.48	29.89	+0.02	71.0	+3.8	99	12	85	38	1	57	40	54	40	42	0.85	-0.1	7	5,996	se.	38	s.	13	15	9	6	4.0	.....	.....
Spokane.....	1,929	101	110	27.92	29.93	+0.01	68.2	+4.8	93	9	82	40	1	54	41	52	39	42	0.43	-1.2	3	3,464	sw.	28	s.	12	10	12	8	4.8	.....	.....
Walla Walla.....	991	57	65	28.88	29.93	+0.03	73.1	+4.9	100	20	87	44	3	59	38	56	42	38	0.10	-1.1	2	3,270	s.	31	s.	12	20	7	3	2.8	.....	.....
North Pacific Coast Region.																																
North Head.....	211	11	56	29.84	30.06	+0.07	53.8	-1.2	70	5	57	46	2	50	16	52	50	89	0.39	-1.4	3	11,229	nw.	44	nw.	18	4	12	14	6.8	.....	.....
North Yakima.....	1,071	4	.....	.....	.....	.....	70.4	.....	98	20	87	39	2	54	43	.....	.....	.....	0.11	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Port Angeles.....	29	8	53	30.05	30.08	.....	55.1	.....	80	65	36	3	45	37	.....	.....	.....	.....	0.29	-1.0	1	4,534	nw.	21	nw.	26	17	7	6	3.9	.....	.....
Seattle.....	125	215	250	29.93	30.06	+0.06	61.6	+1.5	81	21	71	45	1	52	25	53	46	62	0.50	-1.2	4	6,043	n.	25	s.	1	8	17	5	4.9	.....	.....
Tacoma.....	213	113	120	29.82	30.04	+0.01	61.6	+2.2	81	6	72	42	2	51	29																	

TABLE II.—Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1918, at all stations furnished with self-registering gages.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.															
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.		
Ablene, Tex.	7			0.61																0.49			
Albany, N. Y.	12			0.78																0.46			
Alpena, Mich.	6			0.49																0.48			
Anarillo, Tex.	6-7			1.25																			
Anniston, Ala.	2	6:50 p.m.	D. N. p.m.	1.42	7:34 p.m.	8:08 p.m.	0.05	0.28	0.56	0.78	0.95	1.10	1.22	1.30									
Asheville, N. C.	{ 3	11:58 a.m.	4:58 p.m.	2.18	12:45 p.m.	1:57 p.m.	0.03	0.15	0.33	0.65	0.84	1.00	1.13	1.19	1.20	1.26	1.28	1.29	1.79				
	{ 17	12:15 p.m.	12:50 p.m.	0.72	12:20 p.m.	12:36 p.m.	0.01	0.34	0.60	0.69	0.71												
Atlanta, Ga.	{ 6	1:30 p.m.	2:05 p.m.	0.76	1:32 p.m.	1:57 p.m.	0.02	0.20	0.45	0.60	0.68	0.73											
	{ 29	3:25 p.m.	6:52 p.m.	0.82	3:54 p.m.	4:29 p.m.	0.01	0.07	0.12	0.23	0.36	0.47	0.55	0.60									
Atlantic City, N. J.	22			0.94																0.45			
Augusta, Ga.	6			0.69																0.56			
Baker, Oreg.	22			0.12																0.09			
Baltimore, Md.	2			0.42																0.40			
Bentonville, Ark.	29-30	11:20 p.m.	2:40 a.m.	0.82	11:31 p.m.	12:01 a.m.	0.02	0.08	0.20	0.30	0.41	0.51	0.59										
Binghamton, N. Y.	12	2:00 a.m.	4:15 a.m.	1.26	2:26 a.m.	2:53 a.m.	0.20	0.10	0.30	0.41	0.53	0.59	0.64										
Birmingham, Ala.	12	5:12 p.m.	7:06 p.m.	1.49	5:12 p.m.	5:41 p.m.	0.00	0.27	0.71	1.00	1.20	1.36	1.44										
Do.	25	8:13 p.m.	D. N. p.m.	1.18	8:49 p.m.	9:09 p.m.	0.01	0.26	0.59	0.84	0.96												
Do.	29	3:13 a.m.	5:42 a.m.	1.89	3:15 a.m.	3:55 a.m.	0.01	0.19	0.42	0.60	0.77	1.00	1.33	1.66	1.79								
Do.	29	1:49 p.m.	3:14 p.m.	0.71	1:52 p.m.	2:03 p.m.	0.01	0.13	0.43	0.61													
Bismarck, N. Dak.	5			0.34																0.23			
Block Island, R. I.	21-22	11:00 p.m.	10:15 a.m.	3.36	7:31 a.m.	8:28 a.m.	1.58	0.30	0.53	0.60	0.65	0.71	0.77	0.80	1.05	1.27	1.41			1.53			
Boise, Idaho.	23			0.28																0.22			
Boston, Mass.	22			1.20																0.23			
Buffalo, N. Y.	30			0.98																0.52			
Burlington, Vt.	12	11:45 a.m.	2:10 p.m.	0.92	12:19 p.m.	12:41 p.m.	0.07	0.21	0.54	0.66	0.73	0.78											
Cairo, Ill.	5	1:20 p.m.	4:37 p.m.	1.69	1:42 p.m.	2:29 p.m.	0.03	0.10	0.22	0.54	0.82	1.08	1.28	1.39	1.53	1.62	1.64						
Canton, N. Y.	11-12			0.79																0.45			
Charles City, Iowa.	18			0.66																0.42			
Charleston, S. C.	15			0.15																0.15			
Charlotte, N. C.	17			1.06																0.52			
Chattanooga, Tenn.	6	4:38 p.m.	7:03 p.m.	0.71	4:54 p.m.	5:09 p.m.	T.	0.21	0.49	0.57													
Cheyenne, Wyo.	20			0.41																			
Chicago, Ill.	6			0.25																0.39			
Cincinnati, Ohio.	30	1:18 p.m.	1:50 p.m.	0.60	1:34 p.m.	1:44 p.m.	0.04	0.31	0.56											0.24			
Cleveland, Ohio.	6			0.47																0.46			
Columbia, Mo.	24			0.80																0.50			
Columbia, S. C.	17			0.86																0.44			
Columbus, Ohio.	30			0.38																0.35			
Concord, N. H.	7			0.39																0.24			
Concordia, Kans.	24			0.48																0.48			
Corpus Christi, Tex.	{ 15-16	11:37 p.m.	6:30 a.m.	1.19	1:16 a.m.	1:30 a.m.	0.14	0.19	0.45	0.53													
	{ 16	6:45 a.m.	6:05 p.m.	3.10	9:50 a.m.	10:20 a.m.	0.71	0.14	0.32	0.37	0.52	0.71	0.80										
Dallas, Tex.	{ 9	5:50 a.m.	12:43 p.m.	1.53	10:24 a.m.	10:54 a.m.	0.51	0.06	0.21	0.40	0.57	0.66	0.80										
	{ 27	4:01 p.m.	5:30 p.m.	1.25	4:23 p.m.	5:01 p.m.	0.04	0.19	0.58	0.83	0.97	0.99	1.07	1.16	1.20								
Davenport, Iowa.	27	5:27 p.m.	8:50 p.m.	1.45	6:11 p.m.	6:34 p.m.	0.17	0.16	0.43	0.60	0.80	0.85											
Dayton, Ohio.	30			0.42																0.37			
Del Rio, Tex.	8			1.18																0.52			
Denver, Colo.	19			0.25																0.17			
Des Moines, Iowa.	{ 5	11:23 a.m.	12:10 p.m.	1.15	11:41 a.m.	12:03 p.m.	0.01	0.30	0.60	0.85	1.06	1.13											
	{ 24	12:15 a.m.	D. N. a.m.	1.08	12:19 a.m.	12:42 a.m.	0.01	0.14	0.39	0.64	0.90	0.96											
Detroit, Mich.	27	6:55 p.m.	8:40 p.m.	1.17	7:05 p.m.	8:02 p.m.	0.01	0.15	0.30	0.32	0.44	0.72	0.75	0.76	0.77	0.81	0.99	1.15		0.30			
Devils Lake, N. Dak.	5			0.87																0.10			
Dodge City, Kans.	6			0.12																			
Drexel, Nebr.																							
Dubuque, Iowa.	24	8:00 p.m.	D. N. p.m.	1.44	9:03 p.m.	9:53 p.m.	0.11	0.05	0.13	0.20	0.28	0.43	0.63	0.83	1.02	1.11	1.19						
Do.	29-30	D. N. p.m.	8:30 a.m.	1.12	1:26 a.m.	1:55 a.m.	0.12	0.10	0.21	0.25	0.36	0.47	0.55										
Duluth, Minn.	5			0.33																0.27			
Eastport, Me.	12			1.15																0.59			
Elkins, W. Va.	16-17	D. N. p.m.	7:20 a.m.	1.52	3:52 a.m.	4:43 a.m.	0.48	0.10	0.21	0.31	0.41	0.49	0.62	0.68	0.70	0.72	0.81			0.86			
Ellendale, N. Dak.	15	6:25 p.m.	7:30 p.m.	0.98	6:36 p.m.	7:04 p.m.	0.04	0.16	0.47	0.59	0.69	0.86	0.90										
El Paso, Tex.	4			0.30																0.20			
Erie, Pa.	{ 6-7	8:20 p.m.	D. N. a.m.	0.75	9:32 p.m.	10:02 p.m.	0.07	0.11	0.18	0.25	0.26	0.44	0.53										
	{ 11	10:55 p.m.	D. N. p.m.	1.06	11:20 p.m.	11:43 p.m.	0.18	0.11	0.18	0.40	0.77	0.87											
Escanaba, Mich.	30			1.05																0.14			
Eureka, Cal.	13			0.01																0.01			
Evansville, Ind.	20			0.36																0.31			
Flagstaff, Ariz.	24			0.72																0.16			
Fort Smith, Ark.	1	2:46 a.m.	1:18 p.m.	2.28	4:06 a.m.	4:43 a.m.	0.03	0.14	0.30	0.46	0.57	0.59	0.65	0.76	0.81								
Do.	5	8:34 a.m.	12:36 p.m.	1.29	9:36 a.m.	10:04 a.m.	0.17	0.08	0.12	0.26	0.43	0.61	0.68										
Do.	29	1:41 a.m.	3:12 a.m.	0.68	2:02 a.m.	2:25 a.m.	0.02	0.19	0.31	0.40	0.50	0.59											
Fort Wayne, Ind.	{ 27-28	5:30 p.m.	7:40 p.m.	0.74	5:40 p.m.	6:10 p.m.	0.01	0.09	0.21	0.30	0.41	0.58	0.67										
	{ 28	10:15 p.m.	D. N. a.m.	1.30	11:55 p.m.	12:11 a.m.	0.12	0.37	0.81	1.01	1.04												
Fort Worth, Tex.	{ 1	12:03 p.m.	12:39 p.m.	0.92	↑	↑	↑	↑	↑	↑	↑	0.91	0.92										
	{ 8	4:15 p.m.	6:21 p.m.	1.18	4:25 p.m.	5:04 p.m.	0.02	0.12	0.23	0.44	0.65	0.84	0.95	1.01	1.08								
Fresno, Cal.	20			0.01																0.01			
Galveston, Tex.	10	3:26 p.m.	4:40 p.m.	1.84	3:40 p.m.	4:20 p.m.	0.02	0.07	0.27	0.53	1.05	1.25	1.50	1.62	1.71								
Grand Haven, Mich.	30	D. N. a.m.	1:55 p.m.	1.49	3:45 a.m.	4:10 a.m.	0.38	0.09	0.11	0.26	0.46	0.53											
Grand Junction, Colo.	23			0.25																0.19			
Grand Rapids, Mich.	24			0.38																0.29			
Green Bay, Wis.	5			0.62																0.25			
Greenville, S. C.	6	Noon	1:15 p.m.	1.22	12:08 p.m.	12:50 p.m.	0.01	0.16	0.43	0.65	0.72	0.77	0.89	0.97	1.13	1.18							
Do.	17	12:23 p.m.	2:10 p.m.	0.60	2:34 p.m.	2:53 p.m.	0.01	0.21	0.40	0.46	0.52												
Hannibal, Mo.	10			0.33																			

* Self-register not in use.

† Record partly estimated.

‡ No precipitation occurred during month.

TABLE II.—Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1918, at all stations furnished with self-registering gages—Continued.

Stations.	Date.	Total duration.		Total amount of precipi- tation.	Excessive rate.		Amount be- fore excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Knoxville, Tenn.	21	2:50 p.m.	12:45 p.m.	2.52	5:31 a.m.	6:51 a.m.	1.07	0.17	0.26	0.31	0.38	0.47	0.52	0.67	0.73	0.77	0.83	0.92	1.17		
La Crosse, Wis.	8			0.79														0.48			
Lander, Wyo.	20-21			0.84																	
Lansing, Mich.	30			1.13														0.52			
Lewiston, Idaho.	22-23			0.42																	
Lexington, Ky.	24-25	8:45 p.m.	5:30 a.m.	1.87	4:03 a.m.	4:25 a.m.	0.67	0.11	0.20	0.35	0.67	0.73									
Lincoln, Nebr.	1			0.61														0.55			
Little Rock, Ark.	2	8:20 a.m.	11:30 a.m.	1.12	8:50 a.m.	9:53 a.m.	0.05	0.08	0.17	0.27	0.33	0.35	0.41	0.42	0.43	0.53	0.84	0.94	1.01		
Do.	25	6:10 p.m.	9:10 p.m.	1.70	6:49 p.m.	7:33 p.m.	0.01	0.08	0.25	0.53	0.85	1.13	1.36	1.42	1.50	1.65					
Do.	28-29	11:05 p.m.	D.N.a.m.	1.48	11:13 p.m.	11:47 p.m.	0.01	0.14	0.37	0.69	0.92	1.05	1.14	1.18				0.01			
Los Angeles, Cal.	30			0.01														1.17			
Louisville, Ky.	24-25	D.N.p.m.	D.N.a.m.	1.88	1:14 a.m.	2:07 a.m.	0.26	0.17	0.25	0.29	0.38	0.51	0.55	0.58	0.65	0.91	1.06				
Do.	30	11:45 a.m.	12:09 p.m.	0.80	11:55 a.m.	12:06 p.m.	0.02	0.22	0.77	0.80								0.47			
Ludington, Mich.	30			1.02														0.36			
Lynchburg, Va.	25			1.41																	
Macon, Ga.	17	1:55 p.m.	4:15 p.m.	0.98	2:21 p.m.	2:41 p.m.	0.15	0.29	0.55	0.61	0.68										
Do.	29	2:52 p.m.	4:30 p.m.	0.93	2:54 p.m.	3:16 p.m.	0.01	0.19	0.37	0.63	0.79	0.81						0.35			
Madison, Wis.	24			0.87														*			
Marquette, Mich.	*			*																	
Memphis, Tenn.	1	5:40 p.m.	D.N.p.m.	0.95	6:47 p.m.	7:06 p.m.	0.13	0.17	0.39	0.50	0.58										
Do.	5	4:45 p.m.	D.N.p.m.	2.53	5:55 p.m.	7:06 p.m.	0.19	0.16	0.41	0.69	0.95	1.05	1.06	1.06	1.06	1.08	1.22	1.78	2.33		
Meridian, Miss.	2	6:35 p.m.	D.N.p.m.	2.66	6:59 p.m.	7:36 p.m.	0.01	0.33	0.59	1.03	1.55	1.97	2.18	2.31	2.34						
Do.	27	12:45 p.m.	4:35 p.m.	1.14	1:40 p.m.	2:00 p.m.	0.22	0.12	0.24	0.41	0.50										
Miami, Fla.	10	3:13 p.m.	7:10 p.m.	0.94	3:44 p.m.	4:07 p.m.	0.01	0.12	0.40	0.58	0.77	0.83									
Do.	19	6:45 p.m.	9:05 p.m.	1.20	7:00 p.m.	7:43 p.m.	0.03	0.07	0.21	0.34	0.56	0.69	0.73	0.82	0.92	1.00					
Do.	21	11:09 a.m.	11:55 a.m.	0.79	11:14 a.m.	11:30 a.m.	0.01	0.33	0.63	0.75	0.77							0.22			
Milwaukee, Wis.	30			0.40																	
Minneapolis, Minn.	8	6:32 p.m.	D.N.p.m.	1.04	6:41 p.m.	7:05 p.m.	0.01	0.22	0.42	0.61	0.79	0.85									
Mobile, Ala.	26	5:51 p.m.	D.N.p.m.	1.12	5:54 p.m.	6:37 p.m.	0.02	0.13	0.38	0.60	0.71	0.83	0.92	0.97				0.21			
Modena, Utah.	19			0.31														0.35			
Montgomery, Ala.	5			0.54																	
Moorhead, Minn.	25	9:10 p.m.	10:35 p.m.	0.69	9:35 p.m.	9:55 p.m.	0.07	0.09	0.25	0.42	0.50										
Mount Tamalpais, Cal.	12			0.04														0.61			
Nantucket, Mass.	22			2.15																	
Nashville, Tenn.	2	10:45 a.m.	11:20 a.m.	0.76	10:51 a.m.	11:12 a.m.	0.01	0.32	0.49	0.65	0.71	0.75									
Do.	21-22	D.N.p.m.	7:20 a.m.	3.11	3:23 a.m.	4:13 a.m.	1.05	0.05	0.10	0.15	0.22	0.31	0.39	0.45	0.50	0.58	0.72				
New Haven, Conn.	21-22			5:03 a.m.	5:03 a.m.	5:12 a.m.	1.79	1.85													
Do.	22	3:00 p.m.	4:25 p.m.	0.70	3:15 p.m.	3:43 p.m.	0.02	0.15	0.31	0.36	0.40	0.52	0.63								
New Orleans, La.	11	12:35 p.m.	1:05 p.m.	0.58	12:40 p.m.	12:56 p.m.	0.01	0.09	0.35	0.56	0.57										
New York, N. Y.	7			1.22														0.65			
Do.	7	3:25 p.m.	4:20 p.m.	0.67	3:38 p.m.	3:53 p.m.	0.01	0.12	0.40	0.63											
Norfolk, Va.	25-26	3:05 p.m.	6:20 a.m.	2.13	11:42 p.m.	11:19 a.m.	0.53	0.06	0.19	0.30	0.38	0.44	0.49	0.55	0.58						
Northfield, Vt.	12			0.79														0.53			
North Head, Wash.	9			0.19														0.07			
North Platte, Nebr.	5			0.59														0.44			
Okahoma, Okla.	22			0.87														0.80			
Omaha, Nebr.	14			0.36														0.36			
Oswego, N. Y.	21-22			1.04																	
Palestine, Tex.	9			1.17														0.35			
Parkersburg, W. Va.	6-7	7:12 p.m.	1:16 a.m.	1.90	12:07 a.m.	12:44 a.m.	0.20	0.15	0.34	0.59	0.73	0.91	1.02	1.07							
Pensacola, Fla.	12-13	10:55 p.m.	12:10 a.m.	0.62	11:03 p.m.	11:34 p.m.	0.03	0.10	0.18	0.27	0.37	0.45	0.51	0.56							
Peoria, Ill.	24-25	2:50 p.m.	3:25 p.m.	0.54	2:58 p.m.	3:17 p.m.	0.01	0.18	0.35	0.44	0.50										
Do.	6	7:25 p.m.	1:30 a.m.	1.50	10:12 p.m.	10:38 p.m.	0.34	0.33	0.45	0.63	0.80	1.02	1.04								
Philadelphia, Pa.	7			0.45														0.36			
Phoenix, Ariz.	15			0.08														0.05			
Pierre, S. Dak.	25	5:45 p.m.	7:10 p.m.	0.82	5:49 p.m.	6:14 p.m.	0.01	0.43	0.59	0.64	0.72	0.77						0.32			
Pittsburgh, Pa.	17			0.80														0.30			
Pocatello, Idaho.	22			0.34														0.15			
Point Reyes Light, Cal.	12			0.26														0.07			
Port Angeles, Wash.	9-10			0.28														0.18			
Port Huron, Mich.	30			0.20														0.24			
Portland, Me.	22			1.76														0.06			
Portland, Ore.	17			0.08														0.36			
Providence, R. I.	22			2.02														0.21			
Pueblo, Colo.	22			0.29														0.60			
Raleigh, N. C.	21			1.01														0.27			
Rapid City, S. Dak.	22			0.28														0.54			
Reading, Pa.	21-22			1.35														0.04			
Red Bluff, Cal.	12			0.09														0.05			
Reno, Nev.	10			0.05																	
Richmond, Va.	2	7:55 p.m.	9:45 p.m.	1.02	8:46 p.m.	9:18 p.m.	0.01	0.37	0.70	0.75	0.78	0.85	0.95	1.01							
Rochester, N. Y.	11-12	10:40 p.m.	D.N.a.m.	0.73	11:07 p.m.	11:33 p.m.	0.04	0.23	0.35	0.43	0.56	0.62	0.65					0.26			
Roseburg, Ore.	23			0.28														0.10			
Roswell, N. Mex.	4			0.13														T.			
Sacramento, Cal.	16		</																		

TABLE II.—Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1918, at all stations furnished with self-registering gages—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Springfield, Mo.	24-25			1.26														0.90			
Syracuse, N. Y.	11-12	D.N. p.m.	D.N. a.m.	0.90	12:32 a.m.	12:58 a.m.	0.06	0.24	0.41	0.48	0.67	0.78	0.79					0.19			
Tacoma, Wash.	10			0.35														0.35			
Tampa, Fla.	26			0.67														0.25			
Tatoosh Island, Wash.	9			1.48														0.13			
Taylor, Tex.	3			0.24														0.61			
Terre Haute, Ind.	28			1.03																	
Thomasville, Ga.	4	2:02 p.m.	3:45 p.m.	1.23	2:35 p.m.	3:05 p.m.	0.18	0.19	0.52	0.69	0.83	0.87	0.97								
Do.	26	11:10 a.m.	12:09 p.m.	0.96	11:19 a.m.	11:42 a.m.	0.01	0.16	0.35	0.59	0.74	0.80									
Do.	28	3:56 p.m.	5:20 p.m.	1.44	4:19 p.m.	4:52 p.m.	0.11	0.21	0.40	0.72	0.96	1.12	1.24	1.31							
Toledo, Ohio.	30			0.42														0.38			
Tonopah, Nev.	15			0.37														0.29			
Topeka, Kans.	29-30	7:16 p.m.	D.N. a.m.	1.50	7:27 p.m.	7:42 p.m.	0.02	0.21	0.58	0.69											
Trenton, N. J.	5	5:36 p.m.	7:36 p.m.	1.27	6:03 p.m.	6:53 p.m.	0.01	0.09	0.25	0.46	0.57	0.59	0.61	0.72	0.84	1.03	1.10				
Do.	10	6:55 p.m.	8:40 p.m.	0.90	7:02 p.m.	7:20 p.m.	0.01	0.11	0.35	0.54	0.58										
Valentine, Nebr.	5			0.16														0.08			
Vicksburg, Miss.	5	4:28 p.m.	7:30 p.m.	1.55	4:59 p.m.	5:36 p.m.	0.01	0.15	0.35	0.58	0.92	1.20	1.39	1.48	1.51						
Do.	12	6:18 p.m.	D.N. p.m.	1.14	6:19 p.m.	6:39 p.m.	0.01	0.28	0.58	0.77	0.86										
Walla Walla, Wash.	12			0.07														0.04			
Washington, D. C.	1			0.27														0.27			
Wausau, Wis.	27			0.28														0.28			
Wichita, Kans.	29			0.70														0.60			
Williston, N. Dak.	14			0.14														0.12			
Wilmington, N. C.	7-8	8:43 p.m.	D.N. a.m.	1.76	8:43 p.m.	9:31 p.m.	0.00	0.23	0.47	0.61	0.76	0.84	1.02	1.09	1.19	1.26	1.31				
Do.	26	12:08 a.m.	1:40 a.m.	0.66	12:10 a.m.	12:29 a.m.	0.01	0.26	0.38	0.56	0.61										
Winnemucca, Nev.	22			0.66														0.32			
Wytheville, Va.	18	5:25 p.m.	9:50 p.m.	2.06	5:51 p.m.	6:30 p.m.	0.01	0.44	0.77	1.03	1.27	1.45	1.57	1.69	1.76						
Do.	25	7:40 a.m.	D.N. p.m.	2.56	2:57 p.m.	3:27 p.m.	0.89	0.10	0.23	0.30	0.44	0.57	0.63								
Yankton, S. Dak.	2			0.86														0.56			
Yellowstone Park, Wyo.	8			0.76														0.41			

TABLE III.—Data furnished by the Canadian Meteorological Service, June, 1918.

Stations.	Altitude above M. S. L.*	Pressure.			Temperature.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Depart- ure from normal.	Mean max.+ mean min. ÷ 2.	Depart- ure from normal.	Mean maxi- mum.	Mean mini- mum.	Highest.	Lowest.	Total.	Depart- ure from normal.	Total snowfall.
June, 1918.	Feet.	Inches.	Inches.	Inches.	° F.	° F.	° F.	° F.	° F.	° F.	Inches.	Inches.	Inches.
St. Johns, N. F.	125	29.88	30.02	+0.11	50.6	-1.0	61.3	39.9	80	32	4.24	+0.64	.....
Sydney, C. B. I.	48	29.93	29.97	+ .02	54.1	-1.3	63.8	44.4	83	36	3.56	+0.33	.....
Halifax, N. S.	88	29.83	29.93	- .02	56.2	-1.5	65.8	46.6	85	34	4.10	+0.34	.....
Yarmouth, N. S.	65	29.84	29.91	- .04	53.9	-1.1	61.9	46.0	75	34	2.54	-0.22	.....
Charlottetown, P. E. I.	38	29.86	29.90	- .02	56.9	-0.5	65.2	48.7	82	34	3.50	+0.83	.....
Chatham, N. B.	28	29.86	29.88	- .01	57.6	-2.4	68.9	46.3	84	36	4.27	+0.81	.....
Father Point, Que.	20	29.82	29.84	- .03	50.4	-2.6	58.6	42.2	76	33	4.16	+1.18	.....
Quebec, Que.	296	29.55	29.87	- .05	58.0	-3.2	68.5	47.5	82	37	7.60	+3.95	.....
Montreal, Que.	187	29.67	29.87	- .07	61.3	-3.6	70.4	52.3	86	43	4.12	+0.59	.....
Stonecliffe, Ont.	489	29.27	29.87	- .07	58.7	-2.9	71.5	45.9	90	34	1.81	-1.35	.....
Ottawa, Ont.	236	29.62	29.88	- .06	61.7	-3.6	73.3	50.0	90	38	3.53	+0.61	.....
Kingston, Ont.	285	29.60	29.91	- .06	59.9	-3.5	69.7	50.2	82	40	2.04	-0.39	.....
Toronto, Ont.	379	29.52	29.92	- .05	61.5	-1.9	71.6	51.4	89	39	3.35	+0.55	.....
White River, Ont.	1,244	28.56	29.87	- .07	52.1	-6.6	65.6	38.6	76	23	3.21	+0.99	.....
Port Stanley, Ont.	592	29.31	29.95	- .02	61.1	-2.7	71.2	51.0	83	37	2.41	-0.32	.....
Southampton, Ont.	656	29.22	.....	.....	57.7	-2.7	67.7	47.7	83	38	2.39	+0.04	.....
Parry Sound, Ont.	688	29.23	29.91	- .05	59.3	-2.4	69.6	49.0	83	38	2.26	-0.16	.....
Port Arthur, Ont.	644	29.20	29.91	- .03	54.5	-1.9	64.0	45.0	80	35	1.65	-1.08	.....
Winnipeg, Man.	760	29.06	29.88	- .01	60.9	-1.3	73.3	48.5	94	36	3.74	+0.45	.....
Minneapolis, Man.	1,690	28.12	29.91	+ .02	59.7	+0.1	72.4	47.0	97	34	1.31	-1.69	.....
Qu'Appelle, Sask.	2,115	27.66	29.88	+ .01	61.5	+1.6	76.0	47.0	97	28	1.21	-2.21	.....
Medicine Hat, Alberta.	2,144	27.59	29.92	+ .07	68.0	+6.0	83.7	52.4	98	35	1.40	-1.36	.....
Swift Current, Sask.	2,392	27.32	29.83	- .04	64.3	+4.3	80.9	47.8	102	31	1.66	-1.01	.....
Calgary, Alberta.	3,428	26.42	29.89	+ .05	59.9	+3.9	77.0	42.9	90	31	0.26	-2.19	.....
Banff, Alberta.	4,521	25.38	29.88	+ .04	55.5	+4.0	69.9	41.0	82	26	0.94	-2.39	.....
Edmonton, Alberta.	2,150	27.61	29.86	+ .02	57.7	+0.8	69.6	45.9	83	31	3.27	+0.41	.....
Prince Albert, Sask.	1,450	28.34	29.88	+ .01	59.6	+1.9	72.1	47.2	92	32	2.62	+0.11	.....
Battleford, Sask.	1,592	28.15	29.87	+ .01	61.7	+2.2	75.2	48.1	98	32	1.01	-2.30	.....
Kamloops, B. C.	1,262	28.70	29.97	+ .10	65.9	+2.1	79.8	52.1	92	37	0.33	-1.09	.....
Victoria, B. C.	230	29.79	30.06	+ .05	57.9	+1.6	66.4	49.4	80	42	0.33	-0.87	.....
Barkerville, B. C.	4,180	25.74	30.04	+ .17	49.4	-1.3	60.5	38.4	80	28	4.27	+1.36	1.3
Hamilton, Bermuda.	151	29.90	30.06	- .06	75.0	0.0	80.2	69.8	84	66	7.96	+2.01	.....

* See Explanation of Tables in this REVIEW for January, 1918, p. 48.

THE ANNUAL MEETING OF THE SOCIETY OF AMERICAN ARCHITECTS, HELD AT THE UNIVERSITY OF CHICAGO, CHICAGO, ILL., DECEMBER 10-12, 1887.

REPORT OF THE SECRETARY, JAMES H. HARRIS, AND OF THE TREASURER, JAMES H. HARRIS.

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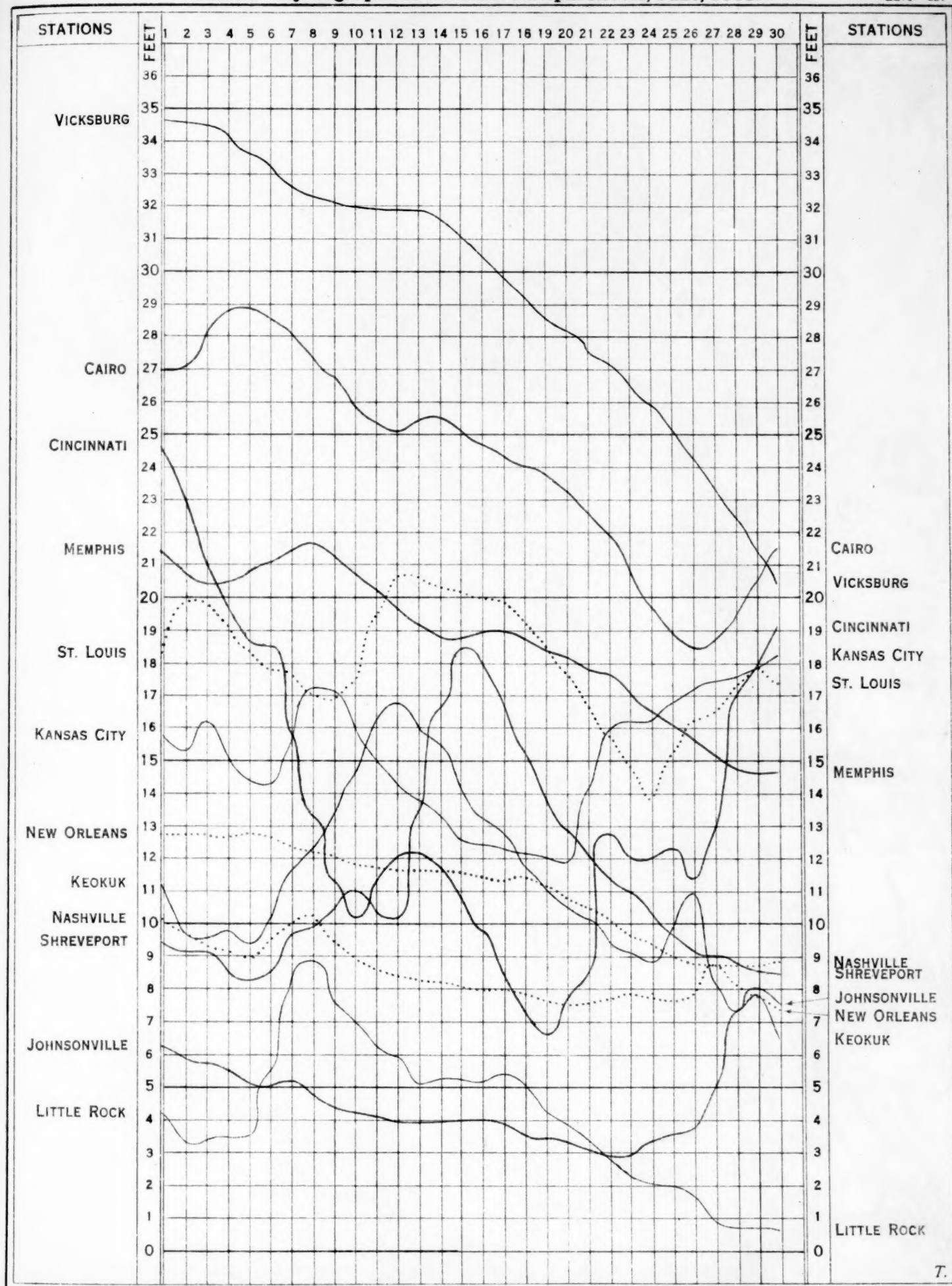
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Chart I. Hydrographs of Several Principal Rivers, June, 1918.

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(Plotted by Charles A. Donnel.)

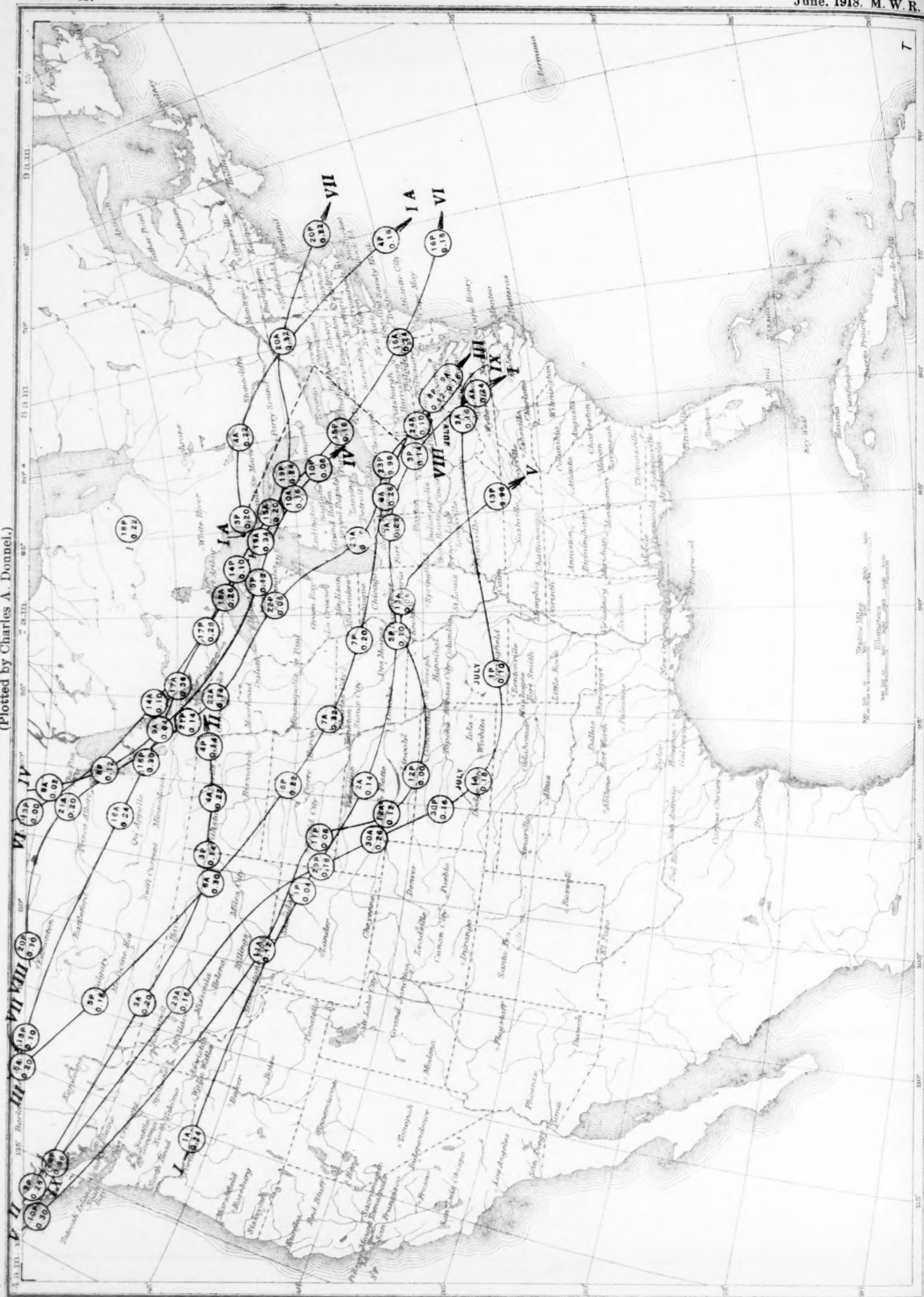


Chart III. Tracks of Centers of Low Areas, June, 1918.

Chart III. Tracks of Centers of Low Areas, June, 1918.
(Plotted by Charles A. Donnel.)

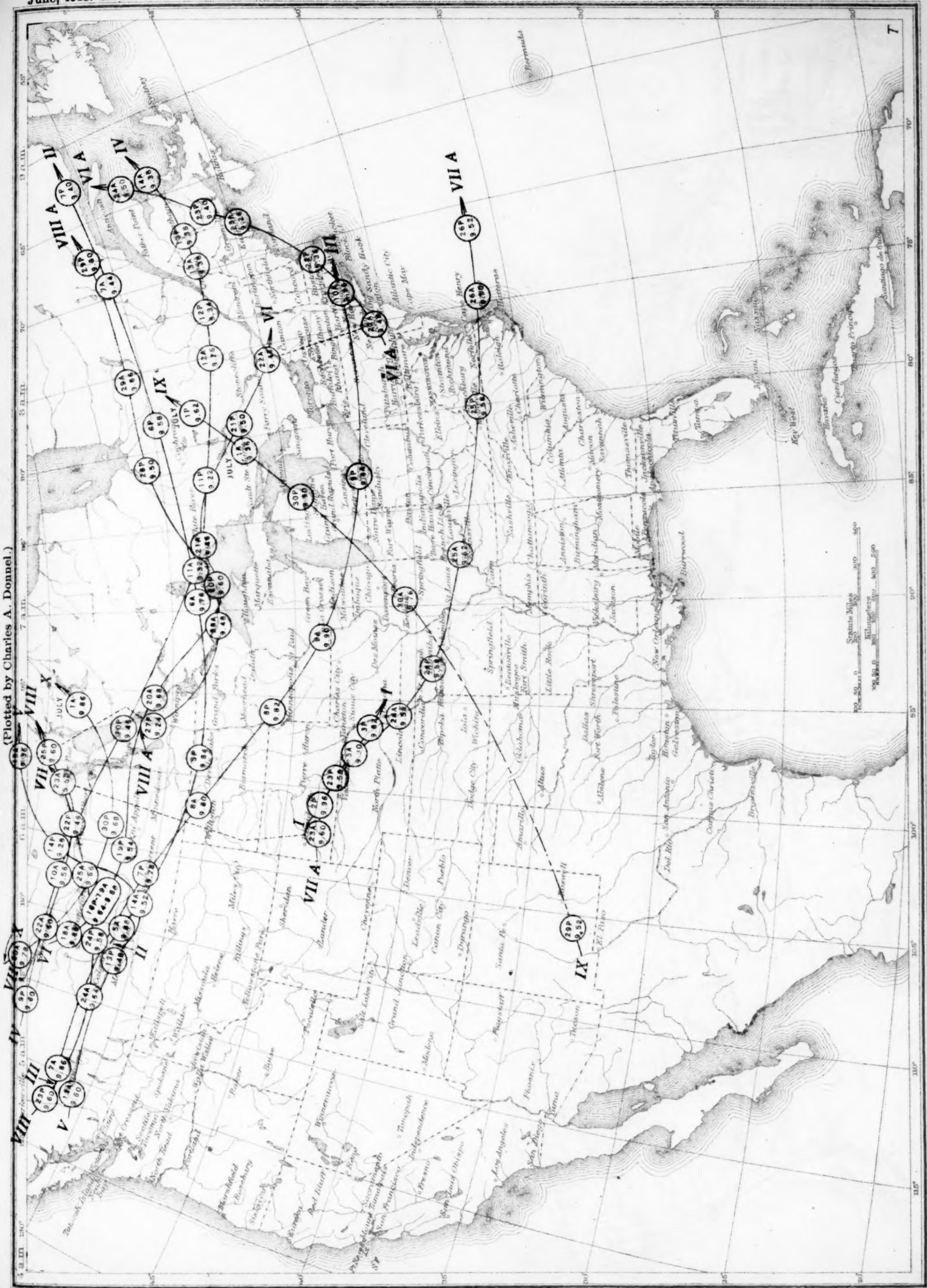


Chart IV. Departure (°F.) of the Mean Temperature from the Normal, June, 1918.



Chart V. Total Precipitation, Inches, June, 1918.

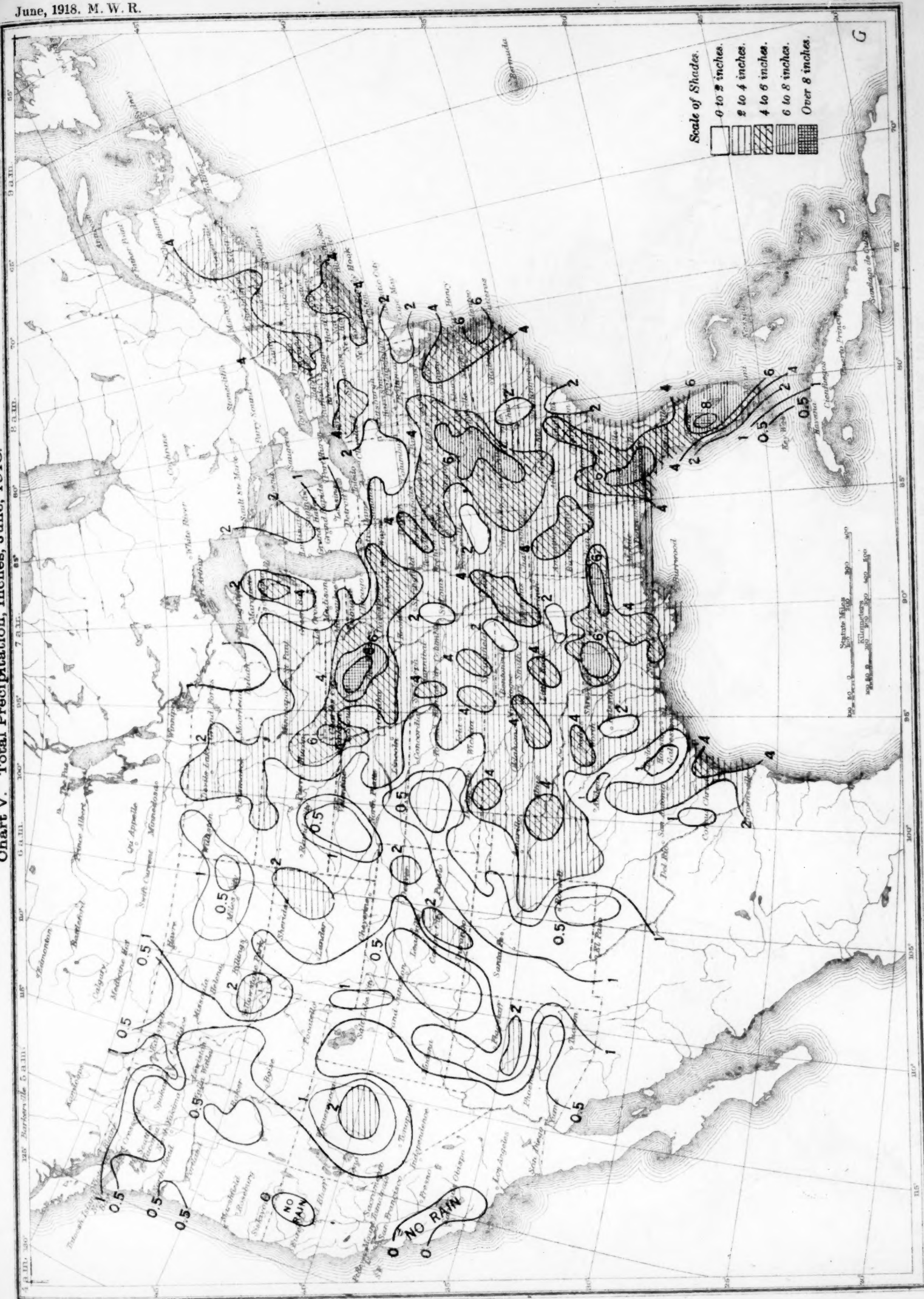


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, June, 1918.

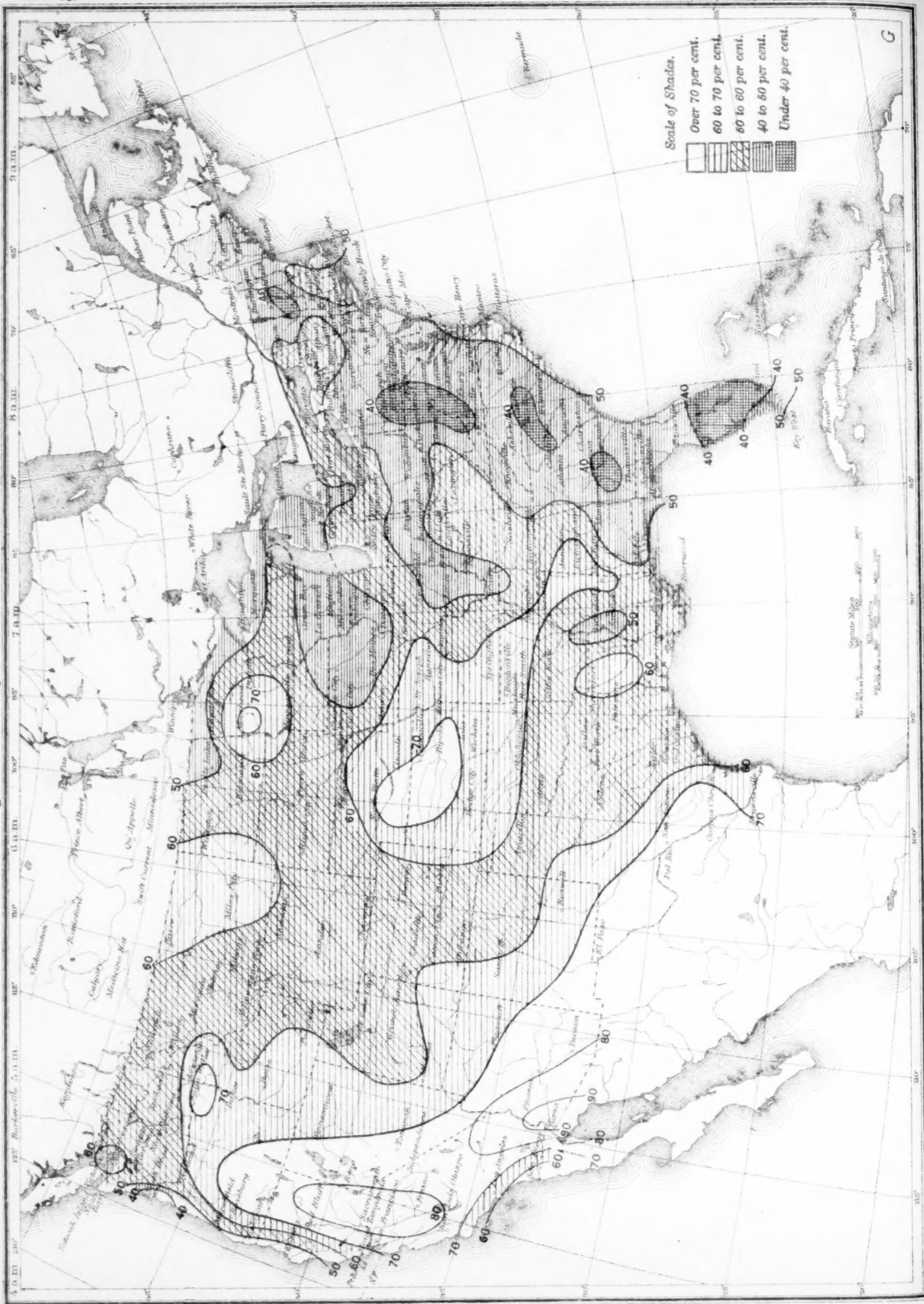


Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, June, 1918.

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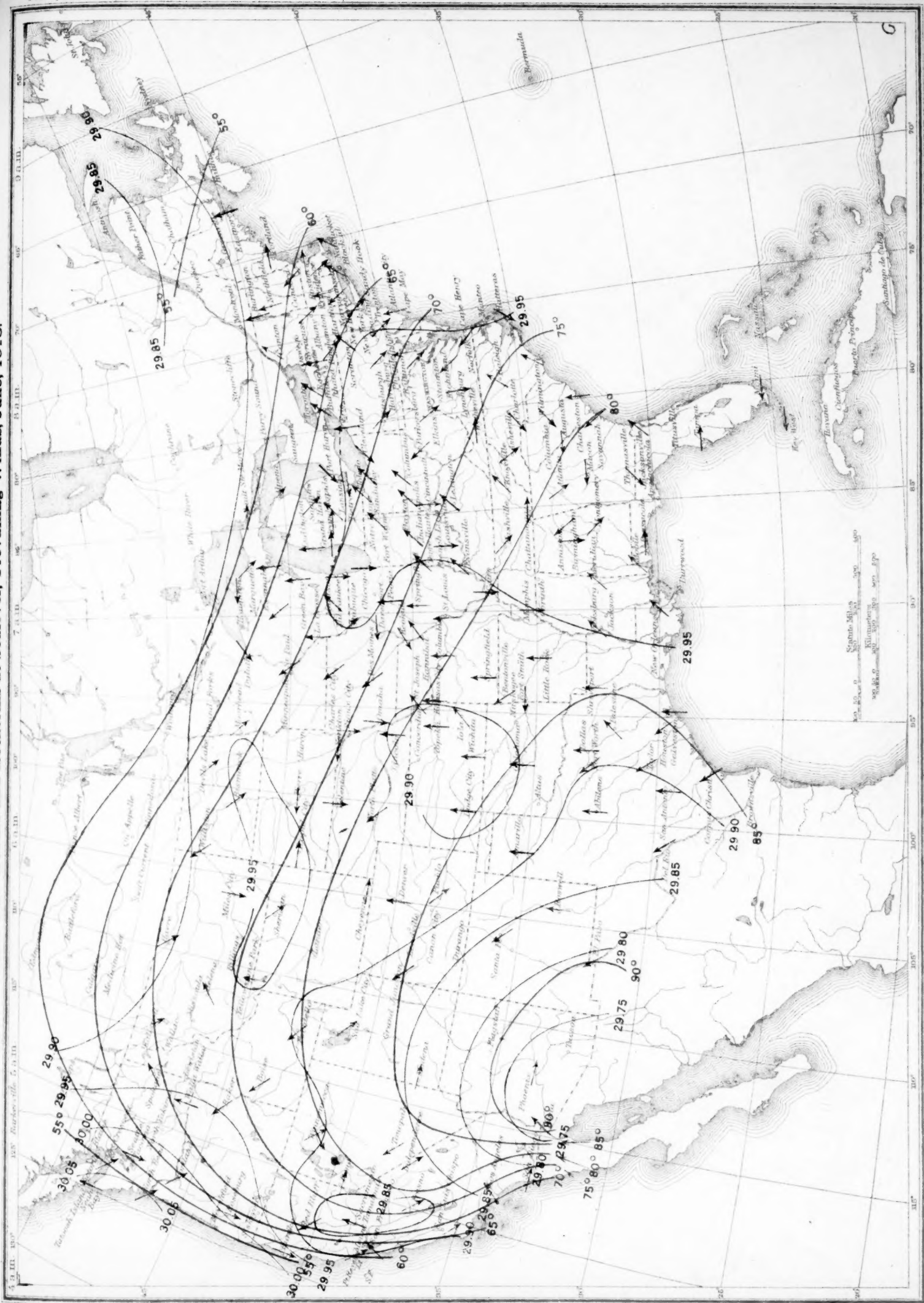


Chart IX. Means of Meteorological Data for North Atlantic Ocean, June, 1917.

(Plotted by F. A. Young.)

